SPECIAL REPORT 95-17

CRREL

Northern Sea Route Reconnaissance Study

A Summary of Icebreaking Technology

Devinder S. Sodhi

June 1995

Abstract
Since the advent of steam power, icebreakers have been built to navigate in ice-covered waters. The hull forms of early icebreakers were merely an adaptation of open water hull shapes, by sloping bow angles more to create vertical forces for breaking ice in bending. However, these bow forms were found to be unsuitable for sea-going vessels because they push broken ice ahead of them. This experience led to construction of all sea-going vessels with wedge-shaped bows from 1901 to 1979. With the introduction of low-friction coatings and the water-deluge system, it is now possible to operate ships with blunt bows efficiently in broken ice. New developments in marine propulsion technology have also been incorporated to obtain better icebreaking efficiency and performance. Both fixed-pitch and controllable-pitch propellers are in use. Nozzles surrounding the propellers are also used to increase the thrust and to reduce ice–propeller interaction. Electrical and mechanical transmission systems have been used in icebreakers to improve the characteristics of the propulsion system. Though many types of prime movers are used in icebreakers, medium-speed diesel engines are the most popular because of their overall economy and reliability. Appendix A is a description of the Russian icebreaker Yamal, which is one of the largest and most powerful icebreakers of the world today. Appendix B contains an inventory of existing ships that are capable of navigating in at least 0.3-m-thick ice. Some of the present icebreakers are capable of navigating almost anywhere in the ice-covered waters of the Arctic and the Antarctic, and multi-purpose icebreakers have been built to operate not only in ice during the winter but also in open water doing other tasks during the summer. With sufficient displacement, power, navigation equipment, and auxiliary systems, future icebreakers that can operate independently year-round in the Arctic and the Antarctic are well within the known technology and operational experience.

For conversion of SI units to non-SI units of measurement consult ASTM Standard E380-93, *Standard Practice for Use of the International System of Units,* published by the American Society for Testing and Materials, 1916 Race St., Philadelphia, Pa. 19103.

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Northern Sea Route Reconnaissance Study

A Summary of Icebreaking Technology

Devinder S. Sodhi

June 1995

Prepared for
U.S. ARMY ENGINEER DISTRICT, ALASKA

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PREFACE

This report was written by Dr. Devinder S. Sodhi, Research Engineer, Ice Engineering Research Division, Research and Engineering Directorate, U.S. Army Cold Regions Research and Engineering Laboratory. It represents a part of the investigations supporting a Reconnaissance Study of the Northern Sea Route. The project was funded by the U.S. Army Engineer District, Alaska. Dr. Orson Smith was the Project Manager.

The author is indebted to Leonid Tunik and Alfred Tunik for compiling the information on icebreakers (presented in Appendix B); Captain Lawson Brigham, Commanding Officer of the USCG *Polar Sea*, for providing information, photographs, suggestions, and valuable background material; Dr. Jean-Claude Tatinclaux, Chief, Ice Engineering Research Division, for providing many references and for reviewing this report; Kevin Carey, Research Hydraulic Engineer, Ice Engineering Research Division, for technically reviewing the manuscript; and Walter B. Tucker, III, Chief of the Snow and Ice Division, for providing information on, and photographs of, the icebreakers at the North Pole. The author thanks the members of the Reconnaissance Study team for their guidance and suggestions.

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INTRODUCTION

In the last four to five decades, many developments in icebreaking technology have taken place through the application of modern marine technology to the design and the operation of polar ships. Innovative ideas have been implemented to improve the propulsion systems and to reduce the resistance encountered during icebreaking. Present navigation and information systems (e.g., ice maps, satellite images, etc.) aboard polar ships enable navigators to identify ice features along the transit route in near real time and to chart a tactical course. As a result of this, it is possible to travel by ships to remote polar regions that were thought to be unreachable only a few years ago. Many nations have contributed to this development by designing and building polar ships and by launching voyages to various regions of the Arctic and the Antarctic. Some of the landmark voyages during the last four decades are listed in Table 1 (Brigham 1992). Recently, Russian nuclear-powered icebreakers have regularly traveled to the North Pole. In August of 1994, the U.S. icebreaker *Polar Sea*, the Canadian icebreaker *Louis S. St. Laurent* and the Russian nuclear icebreaker *Yamal* (App. A) met at the North Pole (Fig. 1).

The impetus behind these technological advances has come from:

1. The exploration for natural resources around the Arctic Basin.
2. The development of the Northern Sea Route by the former Soviet Union, as an integral part of development of the entire Russian Arctic.
3. The need for multi-mission ships for the transportation of personnel, logistics and marine research in the Antarctic.

Although exploration for hydrocarbon resources in the southern Beaufort Sea has almost stopped, plans are being discussed for developments in the offshore areas of the Russian Arctic to produce hydrocarbon resources and to transport them to world markets. Future shipments of these resources will have significant effects on the development of the Northern Sea Route.

From the perspectives of a master mariner, the performance of icebreakers depends on the construction limitations of the vessels and the skills in ice navigation of their captains (Toomey 1994). Although the technological improvements incorporated in the design and construction of an icebreaker help to increase its performance in ice, it is essential to have a skilled captain and crew operating the ship to exploit these advantages to the maximum extent. Therefore, the training and the experience of the crew operating an icebreaker are important elements in its performance. A knowledgeable, skilled captain, supported by extensive information, can prevent or quickly overcome many difficulties along a route.

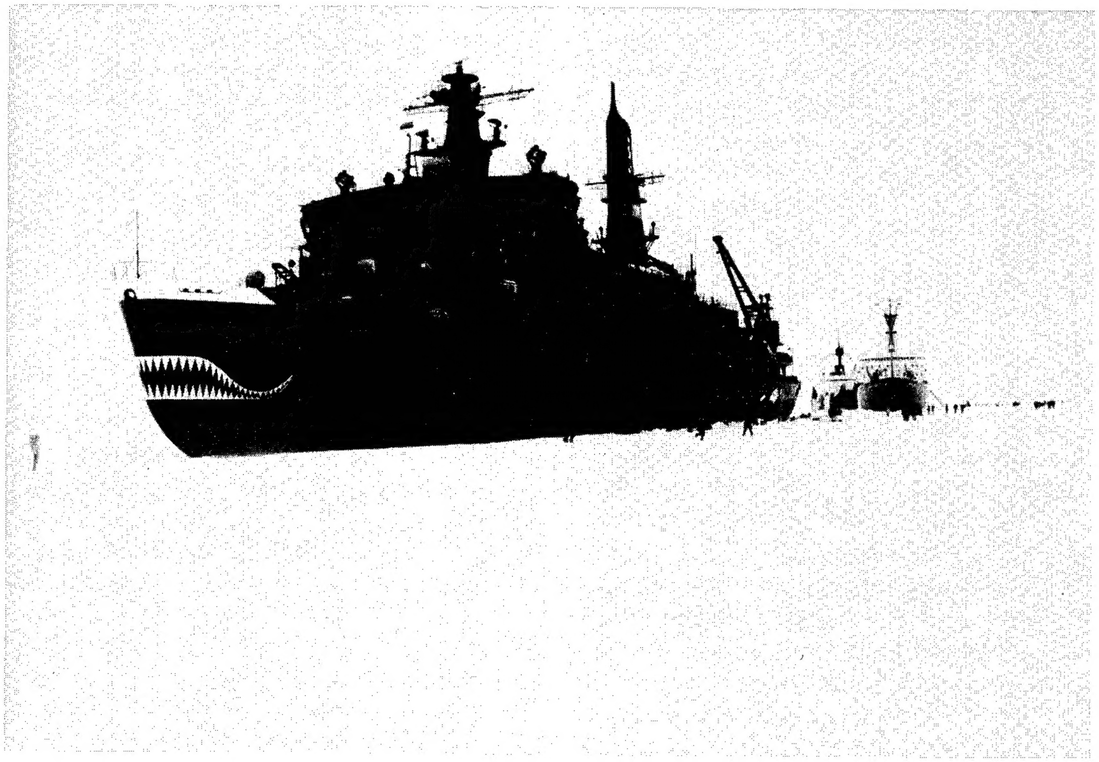
Early history

Johansson et al. (1994) have given an account of the early history of icebreaking ships. Breaking ice with ships was not possible before the advent of steam power. One of the earliest icebreakers, named *Norwich*, was introduced in 1836 on the Hudson River. She had paddle wheels for propulsion and was very effective in breaking ice, remaining in service for 87 years.

By the end of the nineteenth century, only fixed-pitch, screw-type propellers driven with steam power were installed on new icebreakers. Early icebreakers were not powerful, and the hull form was basically adapted from open water hull shapes by sloping the bow angles more to create a vertical force to break the ice in bending. Many innovative designs were proposed and built to increase icebreaking efficiency. For instance, the highly suc-

Table 1. Selected important icebreaking voyages in recent years (after Brigham 1992).

Polar ship/flag	*Time of year*	*Route/location*	*Significance*
Lenin USSR	Summer 1960	Northern Sea Route	World's first nuclear surface ship commences icebreaking escort duties
Manhattan USA	Autumn 1969	Northwest Passage	Experimental voyages to test the feasibility of commercial tankers in the Arctic
Louis S. St.Laurent and *Canmar Explorer II* Canada	Aug 1976	Northwest Passage	Successful escort of a drill ship from the Atlantic to the Canadian Beaufort Sea
Arktika USSR	Aug 1977	Murmansk to the North Pole and return	First surface ship to reach the geographic North Pole (17 Aug)
Sibir' and *Kapitan Myshevskiy* USSR	May–Jun 1978	Northern Sea Route (north of Novosibirskiy Islands)	First high-latitude "trans-Arctic" ice escort
Polar icebreakers and icebreaking carriers USSR	Navigation season 1978–79	Barents and Kara seas	First successful year-round navigation from Murmansk to Dudinka on the Yenisey River
Polar Star and *Polar Sea* USA	1979–86	Bering, Chukchi, and Beaufort seas	Arctic marine transportation ("trafficability") studies around Alaska
Polar Sea USA	Jan–Mar 1981	Bering Sea to Beaufort Sea	First winter transit to Pt. Barrow, Alaska
Polar Star USA	Dec 1982–Mar 1983	Antarctica	First high-latitude (above 60°S) circumnavigation of Antarctica in modern times
Leonid Brezhnev and 12 other icebreakers USSR	Oct–Nov 1983	North coast of Chukotka, Siberia	Rescue of 50 cargo ships trapped in ice
Arctic Canada	Aug 1985	Bent Horn, Cameron Island	First cargo of crude oil from the Canadian Arctic
Vladivostok and *Somov* USSR	Jun–Sep 1985?	Near Russkaya Station, Hobbs Coast, Antarctica	Rescue of Soviet Antarctic Expedition flagship drifting in heavy ice
Three SA-15 icebreaking carriers USSR	Nov–Dec 1985	Northern Sea Route	Experimental navigation season extension with sailings from Vancouver to Arkangel'sk
Icebird FRG	Fall 1985–Summer 1986	Australian Antarctic stations and Japan to Prudhoe Bay, Alaska	Bipolar resupply operations to Antarctica and Prudhoe Bay
Polarstern FRG	Jul–Aug 1986	Weddell Sea, Antarctica	Winter oceanographic operations
Sibir' USSR	May–Jun 1987	Central Arctic Basin	Evacuate drift station 27 and establish drift station 29; second surface ship to reach the geographic North Pole (25 May)
SA-15 icebreaking carriers USSR	Summer 1989	Europe to Japan via the Northern Sea Route	Soviet arctic carriers under charter to Western shippers for commmercial voyages across the top of the Soviet Union
Rossiya USSR	Aug 1990	Central Arctic Basin	Transit to the North Pole (8 Aug) with Western tourists aboard
Arctic Canada	Jun 1991	Northwest Passage to the Polaris Mine, Little Cornwallis Island	Earliest seasonal surface ship transit in eastern reaches of the Northwest Passages; mine reached 23 Jun
Sovetskiy Soyuz USSR	Jul–Sep 1991	Central Arctic Basin and Northern Sea Route	Transit to the North Pole and along the Northern Sea Route with Western tourists
Oden and *Polarstern* Sweden and FRG	Aug 1991	Central Arctic Basin	International Arctic Ocean Expedition; reached the North Pole on 7 Sep
Sovetskiy Soyuz Russia	Jul and Aug 1992	Central Arctic Basin	Reached the North Pole on 13 Jul and 23 Aug
Yamal Russia	Jul and Aug 1993	Central Arctic Basin	Reached the North Pole three times on 13 Jul, 8 and 30 Aug
Yamal and *Kapitan Branitsyn* Russia	Jul 1994	Central Arctic Basin	Reached the North Pole on 21 Jul
Yamal Russia	Aug 1994	Central Arctic Basin	Reached the North Pole on 5 and 20 Aug
Louis S. St. Laurent and *Polar Sea* Canada and USA	Aug 1994	Trans-Arctic Ocean Bering Strait to Svalbard	Reached the North Pole on 22 Aug; encountered *Yamal* at the North Pole



a. Near the North Pole.

b. View from Yamal *(*Polar Sea *is last in line).*

Figure 1. The Russian icebreaker Yamal, *the Canadian icebreaker* Louis S. St. Laurent, *and the U.S. icebreaker* Polar Sea *during the expedition to the North Pole in August of 1994 (photos courtesy W. B. Tucker, III).*

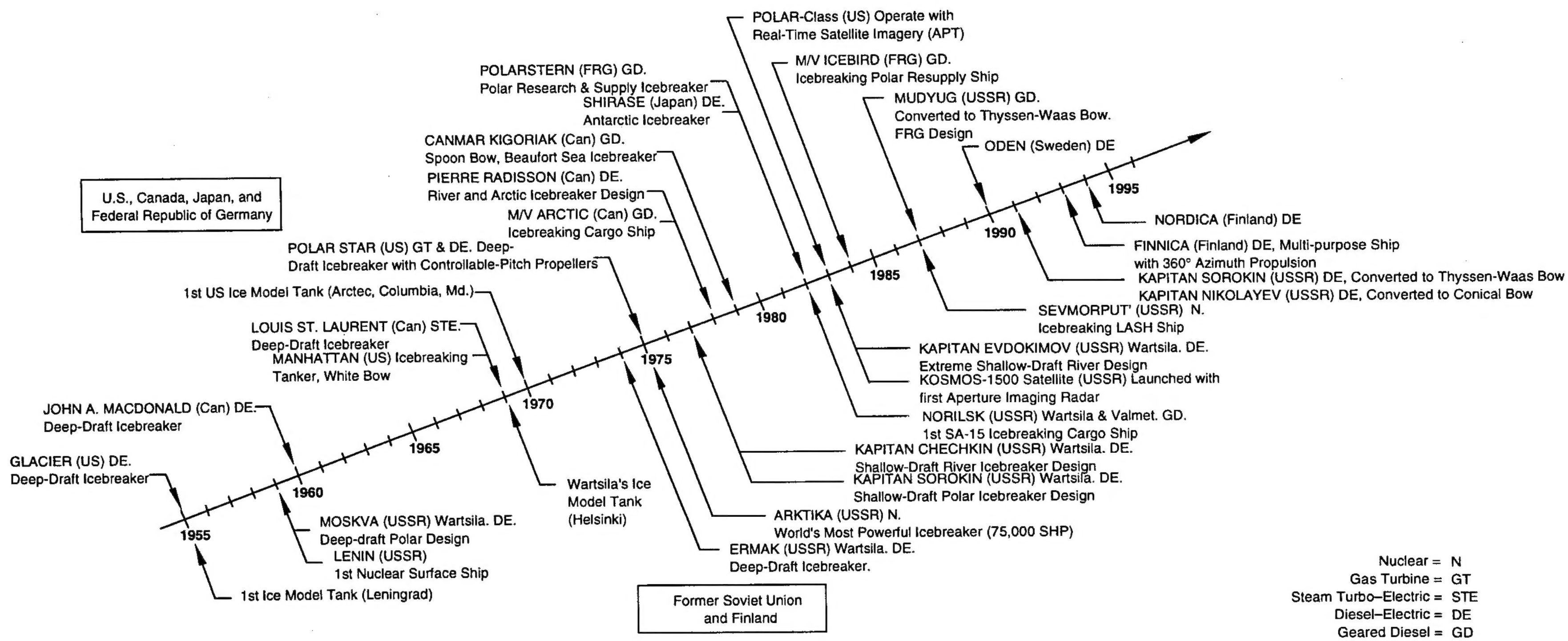


Figure 2. Significant events in the development of polar ship technology since 1955 (after Brigham 1987).

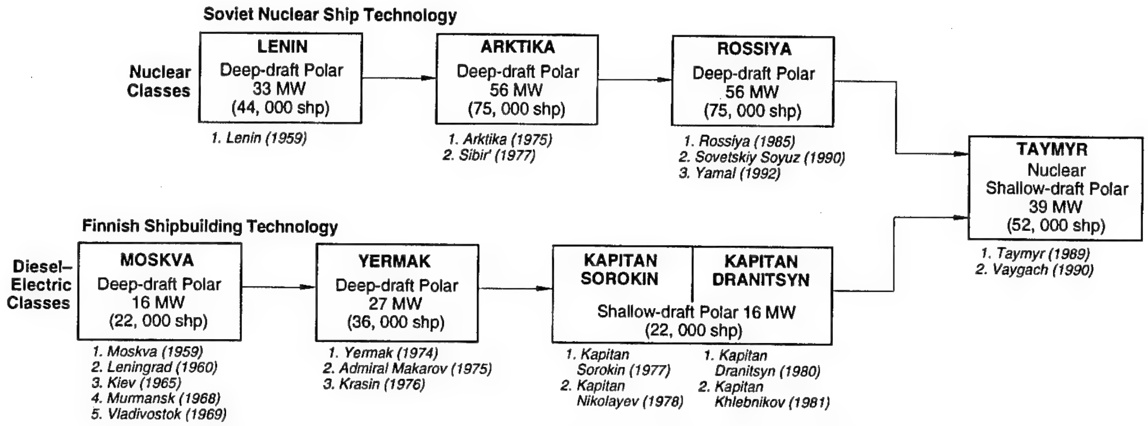


Figure 3. Design evolution of Russian polar icebreakers (after Brigham 1991).

cessful "spoon-shaped" bow was first proposed and built by Ferdinand Steinhaus of Hamburg in 1871. In 1892, Weedermann invented and patented a device to be placed in front of a ship having a bow not suitable for icebreaking on its own. These devices are still used on Dutch rivers and canals.

By 1900, it was well understood that, while ships with blunt bows are efficient in breaking level ice in sheltered areas, such as rivers, lakes and other protected areas, their performance in rubble ice is poor because they have a tendency to push broken ice ahead of themselves. On the other hand, ships with wedge-shaped bows and sharp stems did not have any tendency to push rubble ice. This experience led to all sea-going ships built between 1901 and 1979 having a wedged-shaped bow and a sharp stem (Johansson et al. 1994). Over the years, the wedge-shaped bows became known as "conventional" bows, and the other shapes as "unconventional" bows.

The development of the bow form remained stagnant in the early and middle part of the 20th century (Johansson et al. 1994). This can be attributed partly to other priorities caused by the two World Wars and by the slowdown of economic acivity during the large-scale recession of the 1930s. Despite this stagnancy in bow design, other innovations were introduced during this time. The Russian icebreaker *Yermak*, built in 1899 and fitted with propulsive machinery of 7.46 MW (10,000 hp), had considerable effect on the icebreaking technology at the turn of this century by becoming a pioneer in many untested offshore areas. In 1933, diesel-electric propulsion was introduced on the Swedish icebreaker *Ymer*. In 1947, twin bow propellers were introduced on the Canadian icebreaking ferry *Abgeweit*. (However, the use of bow propellers has now been discontinued because of their interference with ice.)

Recent history

Figure 2 shows a summary of significant advances in the polar ship technology during the past four decades, as outlined by Brigham (1987), made by Finland and the former Soviet Union, and by the U.S., Canada, Germany and Japan. Together, Finland and the Soviet Union have made enormous contributions to the development of polar ships.

The Soviet Union first used nuclear technology to power the icebreaker *Lenin*, which was built in 1959 with a propulsive power of 29 MW (39,000 hp). The Finnish shipbuilder, Wärtsilä Shipyard (now Kværner Masa-Yards), built many icebreakers for the Soviet Union and created extensive design evolution during the years of the development of conventionally powered icebreakers. Recently, these two technologies have merged, as shown in Figure 3, to develop the *Taymyr*-class (Fig. 4), shallow-draft polar icebreakers built in Helsinki with Soviet nuclear propulsion systems installed in St. Petersburg.

Similarly, developments in the U.S. and Canada have contributed to changes in key areas of icebreaking technology (e.g., hull and bow form, gas turbines, and controllable-pitch propellers). In 1969, the U.S. modified tanker *Manhattan* had tenfold the displacement of earlier icebreakers, giving her great ramming capability. In the early 1980's, modern hull and propulsion technologies were also applied to Antarctic ships (e.g., Japan's *Shirase*, and Germany's *Polarstern*). The bows of three icebreakers were converted to the newly developed Thyssen-Waas bow: *Max Waldeck* in 1980, *Mudyug* in 1986 and *Kapitan Sorokin* in 1991. The results of full-scale trials in open water and in ice indicate that this change in the bow of *Mudyug* has increased her icebreaking capability in level ice at reduced power requirements (Milano 1987). However, there were problems with wave slam-

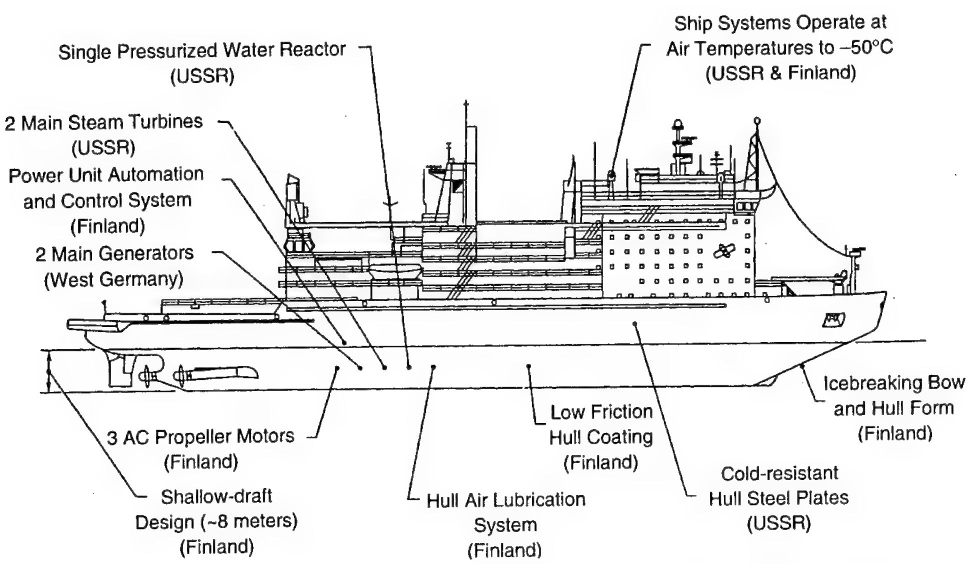


Figure 4. Taymyr-*class shallow-draft nuclear icebreaker (after Brigham 1991).*

ming in open water operations during high seas, and with the front of the ship pushing rubble ice (Ierusalimsky and Tsoy 1994).

In 1979, the Canadian icebreaker *Kigoriak* was built with a spoon-shaped bow for operations in the Beaufort Sea. Extensive full-scale experience indicated that even this modern version of the spoon-shaped bow was not immune to the ice-pushing problem. However, these problems were solved by using epoxy paint and a water-deluge system to reduce friction between the broken ice pieces and the hull. The water-deluge system lifts several tons of water every second and pours it on top of the ice in front of the bow. This helps to move the ice pieces past the ship by submerging them. In the early 1980s, several ships in Canada were built with spoon-shaped bows. Some of the recent icebreakers built in Europe have also been built with these bows, e.g., the Swedish icebreaker *Oden*, built in 1989, the Russian icebreaker *Kapitan Nikolayev*, converted in 1990, and the Finnish icebreakers *Finnica* and *Nordica*, built in 1993 and 1994.

With the introduction of low-friction coatings and auxiliary systems, the capabilities of present icebreakers are greatly enhanced so that they can make steady progress in all types of ice conditions. With sufficient displacement, power and auxiliary systems, future icebreakers that can operate independently year-round in the Arctic are well within the known technology and operational experience (Keinonen 1994). As in the past, the construction of future icebreakers and icebreaking cargo ships will be closely linked to economic conditions and pressures. Choices between dedicated icebreaking ships and multi-purpose ships will be dictated by the needs of future developments and trade.

INVENTORY OF ICEBREAKING SHIPS

Icebreaking ships that will be built in the future may have their designs based on the present state of icebreaking technology and may also incorporate innovative developments in many areas of marine technology. Past experience can help designers avoid mistakes, but accepting the present status too rigidly can also discourage them from innovation. Improvements in the design of icebreakers should result from a full understanding of the current status of icebreaking technology.

Information on most of the icebreaking ships in the world is given in the appendix of the review paper by Dick and Laframboise (1989), and an updated and a modified version of this list is also included in the appendix of a report by Mulherin et al. (1994). The latter database contains information on icebreakers and icebreaking cargo ships from the following countries: Argentina, Canada, Denmark, Finland, Japan, Sweden, United Kingdom, Russia (or former Soviet Union), U.S. and Germany.

An inventory of all ships that are capable of navigation in at least 0.3-m- (1-ft-) thick ice has been prepared for this study. This information has been assembled in an electronic database and is also presented in Appendix B. The database con-

tains technical and other forms of information on each series of ships. Technical information consists of length, beam, depth, draft, deadweight, displacement, propulsion machinery, nominal speed, bow shape, propulsion power, fuel capacity, fuel rate, etc. Non-technical information consists of the name (or former name), names of sister ships, ownership, shipyard and year of construction, home port, ice classification, etc.

SIZES AND DIMENSIONS

The main dimensions of a polar ship are its length, beam width and depth. The draft is the depth of the ship's keel below the waterline, whereas the depth is the distance between the keel and the deck. The depth of water in which a ship can operate without touching bottom depends on the draft. Figure 5a shows plots of the dimensions of icebreakers (cargo ships not included) as compiled by Dick and Laframboise (1989), whereas Figure 5b shows the dimensions of all ships as compiled in the database given in Appendix B. The scatter in the plot of data in Figure 5b is greater than that in Figure 5a, because ships listed in Appendix B are not only icebreakers but also other ships having some icebreaking capability. The trends of the lines shown in Figure 5a pertain only to icebreakers, whereas the lines of best fit shown in Figure 5b pertain to the data on vessels listed in Appendix B.

Beam

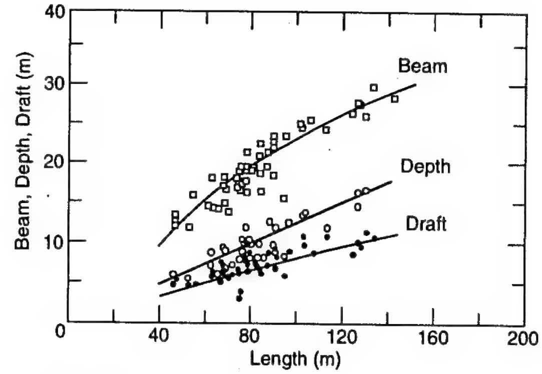
In Figure 5a, the mean length-to-beam ratio of icebreakers varies from 3.6 to 4.6 for lengths from 40 to 140 m respectively. North American vessels are narrower than those from Finland, Sweden and Russia. This may be attributed to the practice of convoy escort used in the Baltic Sea and Russian Arctic. The line of best fit in Figure 5b has an intercept of 6.7 m and a slope of 0.102 m/m.

Depth

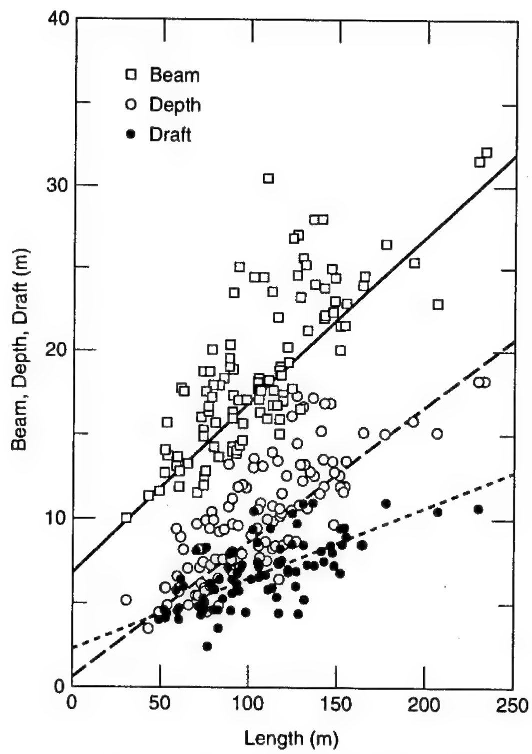
In Figure 5a, the mean length-to-depth ratio of icebreakers varies from 8.9 to 8.2 for lengths from 40 to 140 m respectively. This ratio is high for supply vessels and low for conventional icebreakers. The line of best fit in Figure 5b has an intercept of 0.6 m and a slope of 0.08 m/m.

Draft

In Figure 5a, the mean length-to-draft ratio of icebreakers varies from 11.4 to 12.2 for lengths from 40 to 140 m respectively. Draft, like other dimensions, is usually defined by the operating requirements of the ship. The line of best fit in Figure 5b has an intercept of 2.2 m and a slope of 0.042 m/m.



a. Icebreakers (cargo ships not included) (after Dick and Laframboise 1989).



b. All vessels included in the inventory of ships listed in Appendix B.

Figure 5. Dimensions of vessels.

Maximum deadweight

Figure 6 shows a plot of deadweight at maximum draft vs. the overall length of the vessels listed in Appendix B. The curve shown in Figure 6 is a best fit quadratic curve having the following equation

$$D_{max} = -4545 + 18.81\,L + 0.61\,L^2$$

where D_{max} is the maximum deadweight and L is the overall length of a vessel.

HULL FORMS

The primary consideration for the choice of hull form of an icebreaking ship is the lowest power required to make progress in ice. Power in open water, maneuvering and protection of propellers from ice are some of the secondary considerations. The following are factors that need to be considered while selecting a hull form (Dick and Laframboise 1989):

1. Performance in ice of all types.
2. Performance in open calm water.
3. Performance in heavy weather in open water.
4. Maneuvering capability.
5. Overall dimensions.
6. Ease and cost of construction.
7. Ease of repair and type of ship (e.g., cargo, icebreaker, etc.).

Because some of the objectives listed above are in conflict with each other, the best hull shape is one that takes into account the overall operations of a vessel. Most of the sea-going icebreaking ships have been constructed with conventional bows. However, there have been a few departures from this trend in the recent past, and a few ships have been built with unconventional bows out of particular considerations of costs, icebreaking efficiency or maneuvering. Auxiliary systems have to be furnished so that a ship with an unconventional bow can operate effectively in rubble ice as well as in level ice.

Bow shape

The bow shape of an icebreaker is characterized by five basic design features, shown in Figure 7. Flare angles contribute to the efficiency of icebreaking and ice block submergence, whereas waterline angles contribute to clearing efficiency. Buttock angle and stem angle are associated with the flare and waterline angles, and these also contribute to breaking and submergence efficiencies.

The progression in the design of icebreaker bows over the last two decades has been to increase flare angles, to reduce waterline angles and to reduce stem and buttock angles (Dick and Laframboise 1989). These changes have resulted from a systematic series of model tests to produce a more efficient icebreaking bow. Over the years, the values of stem angles of icebreakers have decreased from 30 to 20°.

The selection of bow shape is greatly influenced by the mission profile of a polar ship. Different bow shapes that have been used are shown in Figure 8 (Dick and Laframboise 1989), and a brief discussion of each follows.

Straight stem with parallel buttocks

This shape has been commonly used for Soviet and Finnish icebreakers since the 1950s, as dem-

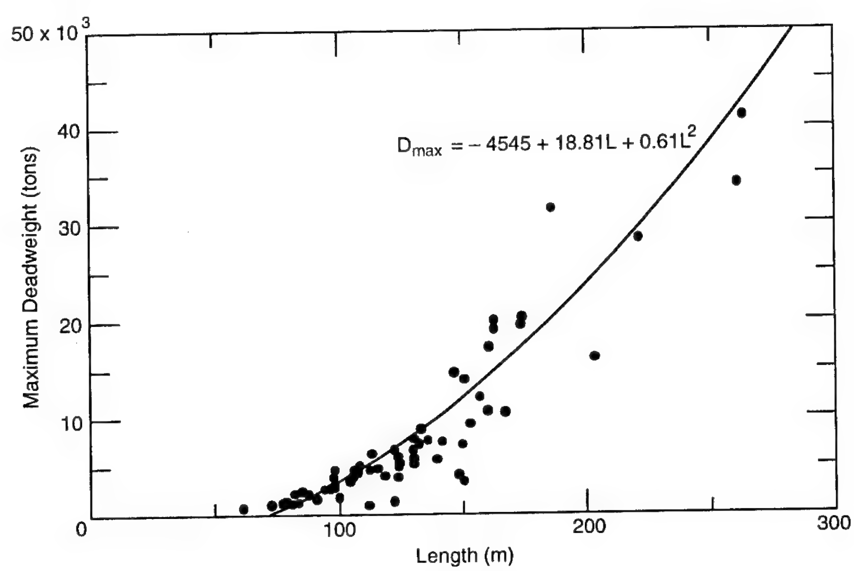


Figure 6. Maximum deadweight vs. overall length of all vessels listed in Appendix B.

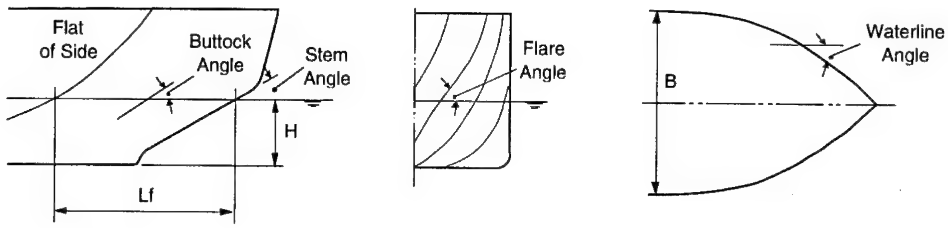


Figure 7. Main features of bow forms (after Dick and Laframboise 1989).

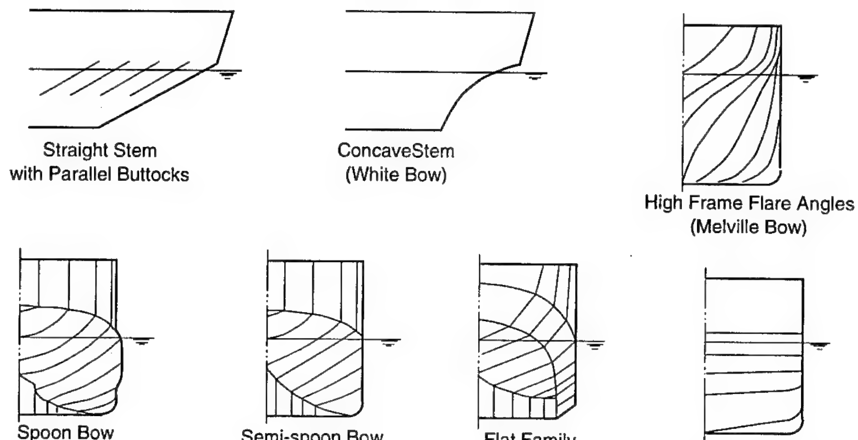


Figure 8. Different shapes of icebreaking bows (after Dick and Laframboise 1989).

onstrated by the *Moskva*-class icebreakers in the 1960s, and the *Urho*-class Baltic icebreakers in the 1970s.

Concave stem (White bow)

Although the concave stem had been used in earlier icebreakers, R. White developed this particular shape in 1969 for efficient icebreaking and ice clearing. This bow shape was used in the U.S. icebreakers *Polar Star* and *Polar Sea*, built in the mid-1970s, in the Canadian icebreaking cargo ship *Arctic*, built in the late 1970s, and in the Canadian R-class icebreakers, built between 1978 and 1984. Because of the concave stem, this bow shape has higher frame flare angles close to the stem.

High flare angles (Melville bow)

This shape was developed to reduce the icebreaking component of ice resistance. Recently, the Canadian icebreaking cargo ship *Arctic* was modified to this type of bow, and its performance increased from 1 to 4 m/s (2 to 8 knots) in 1-m-thick ice.

Spoon bow with reamers

The spoon-shaped bow has been more efficient because this shape allows a constant frame flare angle throughout the bow length. As mentioned earlier, this shape was used in the past, but its use was discontinued because of its high resistance in heavily snow-covered ice, and its tendency to push broken ice in front of the ship. With the introduction of bubbler systems or water wash systems, these problems have been overcome.

A modification of this shape was reintroduced on the Canadian icebreakers *Canmar Kigoriak*, built in 1979, and *Robert Lemeur*, built in 1981. The extended beam at the shoulder (reamers) with the abrupt change in shape eliminates midbody resistance by cutting a wider channel in ice, but it causes extra resistance in open water. Recently, this shape was also used in the European icebreakers *Oden*, *Kapitan Nikolayev*, *Finnica* and *Nordica*. The hull form of the Finnish multipurpose icebreakers *Finnica* and *Nordica* is shown in Figure 9, which also shows the icebreaking stern and the bi-directional reamers on the sides.

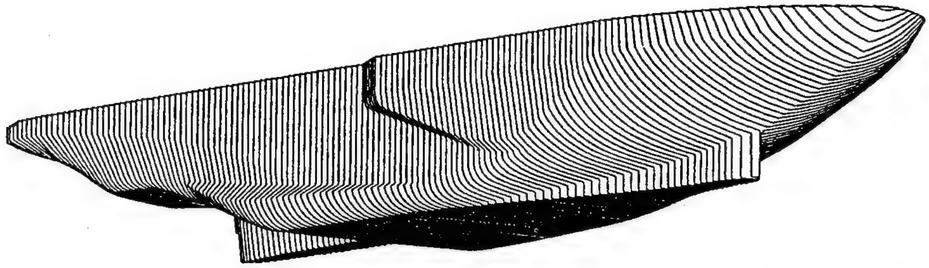


Figure 9. Hull form of the Finnish multipurpose icebreakers Finnica *and* Nordica *(after Lohi et al. 1994).*

Semi-spoon bow with chines

This shape is similar to the spoon bow shape, except that the extended beam (reamers) are replaced by shoulder chines. This shape has been used on vessels working in the Beaufort Sea, and it has improved icebreaking performance. But it has had some detrimental effect on the open-water resistance.

Flat family

These shapes are similar to the spoon bow and semi-spoon bow shapes, except that flat plates have been used to reduce the construction costs. This shape was developed as a compromise between icebreaking capabilities and construction costs. This type of bow has been used on the Canadian vessels *Arctic Nanabush*, built in 1984, and *Arctic Ivik*, built in 1985, both being used for ice management in the Beaufort Sea.

Thyssen-Waas bow

This type of bow shape is a significant departure from a conventional icebreaking bow. The bow first breaks the ice by shearing at the maximum beam of the ship, and then breaks the ice in bending across the front of the bow. This shape is characterized by flat waterlines at the extreme forward end, extended beam, a low stem angle with an ice clearing forefoot, and high flare angles below the waterline. The ice clearing capability is so good that the channel behind the ship is about 85% free of ice. As mentioned earlier, the vessels that have been fitted with this type of bow are the *Max Waldeck* (1980), the *Mudyug* (1986) and the *Kapitan Sorokin* (1991).

Of the seven bow shapes listed above, the first three can be called "conventional" or "traditional," because these shapes retain the smooth hull, which offers the least resistance in open water. The other four shapes are "unconventional" or "nontraditional," in that these shapes are a distinct departure from the smooth hull shapes. Each shape has some benefits and some drawbacks. Therefore, the selection of a bow shape should be based on a full understanding of the operational requirements of a ship.

Midbody shape

The midbody shape of a polar ship is characterized by three parameters: flare angle, parallel sides and longitudinal taper (Dick and Laframboise 1989). The objective of midbody flare is to decrease the resistance caused by it while passing through the channel broken by the bow. Some of the icebreaking cargo ships have a long, parallel midbody. Some of the icebreakers have forward shoulders to break a wider channel to eliminate any ice resistance from a parallel midbody. Similarly, a midbody with longitudinal taper eliminates ice resistance aft of the forward shoulders. This shape has been used on barges pushed by small tugs that operate in sheltered water. The drawbacks of longitudinal taper in the midbody are higher construction costs and an increased probability of getting stuck in pressured ice. A longitudinally tapered midbody is not used on icebreakers or icebreaking cargo ships.

Stern shape

All icebreakers must move astern in ice. Some icebreakers may move back only in the previously broken channel or in broken ice. But there are those icebreakers providing a support role that must break ice while moving astern. Depending upon the mission profile, these ships may have an ice breaking–deflecting stern shape, as shown in Figure 9. The main concern while moving astern is the ingestion of ice blocks into the propellers. Despite many innovative stern designs and shrouded propellers, there is still considerable interaction between ice and propellers (Dick and Laframboise 1989).

Icebreaker performance with different hull forms

Ierusalimsky and Tsoy (1994) presented the results of full-scale tests conducted on three Russian sister ships of the *Kapitan Sorokin* series with different hull forms: *Kapitan Sorokin*, converted to a Thyssen-Waas bow in 1991, *Kapitan Nikolayev*, converted to a conical bow (similar to the spoon-shaped bow) in 1990, and *Kapitan Dranitsyn*, still with the original, wedge-shaped bow. The data on the performance of these ships were obtained over 3 years, enabling a determination of any cost saving resulting from the conversion to bows of different shapes.

For breaking a level ice sheet in forward motion, Figure 10 plots ship performance in terms of the continuous speed of these three ships in equivalent ice thicknesses. The plots in Figure 10 show that *Kapitan Sorokin* with the Thyssen-Waas bow has the best icebreaking capability among the three in level ice, closely followed by the *Kapitan Nikolayev* with the conical bow. The performance of these two ships is much better than that of *Kapitan Dranitsyn* with its original bow. While breaking a channel in fast ice, *Kapitan Sorokin* left up to 40% of the ice in the channel behind it, whereas the other ships left 80–90% of the channel filled with ice. A similar test for backward motion in level ice revealed their performance in reverse order as that for forward motion.

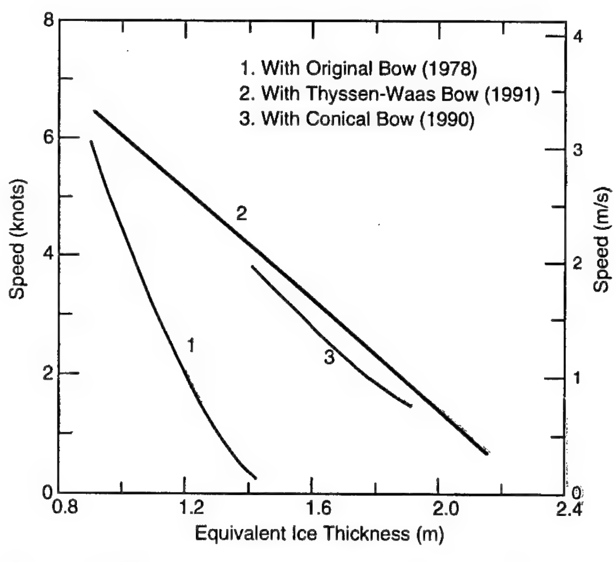


Figure 10. Icebreaking capabilities of three sister ships with different bow shapes in terms of speeds in level ice of different thicknesses at a power level of 16.2 MW (after Ierusalimsky and Tsoy 1994).

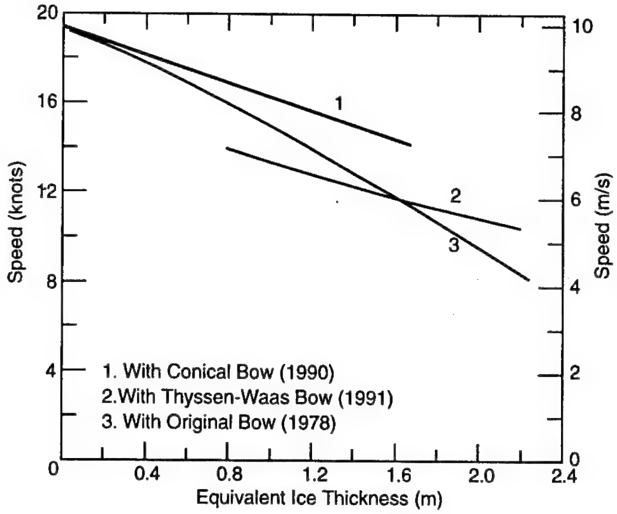


Figure 11. Ship speed vs. equivalent ice thickness during tests in broken ice with three sister ships having different bow shapes. The ships were tested in their own channels (after Ierusalimsky and Tsoy 1994).

Figure 11, giving the results of the tests conducted in freshly broken ice in their own channel, shows that the performance of *Kapitan Nikolayev* is better than that of the other two ships. For tests conducted in broken ice in old channels, *Kapitan Nikolayev* performs better than *Kapitan Dranitsyn.* In old channels full of broken ice, *Kapitan Sorokin* had a tendency to push broken ice ahead of itself when it was not able to reach a speed of 3–4 knots (1.5–2 m/s). Three rounded knives in the bow of *Kapitan Sorokin* work efficiently to break level ice, but they also obstruct the flow of broken ice underneath the bow. At times, the buildup of an ice pile can bring the ship to a standstill, and force it either to ram through the pile or to seek a new path. While operating in drifting broken ice at speeds up to 3–4 knots, *Kapitan Sorokin* showed tendencies to push ice. The performance of *Kapitan Nokilayev* improved in drifting ice fields.

Both ships with the Thyssen-Waas and conical bows must reduce speeds in severe seas because of considerable wave slamming in a head sea, resulting in longer travel times.

Ierusalimsky and Tsoy (1994) have compared the cost savings as a result of conversion of bow shapes from conventional to the two types of unconventional shapes. According to them, *Kapitan Nikolayev*, with the conical bow, had reduced operational costs and increased profitability, whereas similar measures for *Kapitan Sorokin*, with the Thyssen-Waas bow, were less favorable than those for the ship with the original bow. It should, how-

ever, be noted that *Kapitan Nikolayev* is fitted with stainless steel compound plate in the ice belt area, which may be effective in reducing the chances of getting stuck in ice.

STRUCTURAL DESIGN OF POLAR SHIPS

Structural design involves the selection of material and sizes of plates and frames for maintaining the structural integrity of a polar ship under loads from waves and ice during its normal operation (Dick et al. 1987). As a result of research and experience, much has been learned about the nature of ice loads and the mechanics of ice failure. Full-scale measurements of ice loads on many ships have yielded an empirical description of ice forces and pressures that is used in design. The magnitude of ice loads, the existence of significant damage and the emergence of affordable nonlinear finite element analysis packages have together led to the wide use and acceptance of plastic design (plastic design allows some deformation of the structure under extreme ice loads).

Classification of polar ships

All commercial vessels, including most icebreakers, but excluding government-owned vessels, are classified according to the rules developed by six classification societies: Lloyds Register (LR), Det norske Veritas (DnV), American Bureau of Shipping (ABS), Bureau Veritas (BV), Germanischer Lloyd (GL), and Russian Register of Shipping (RS). Besides the rules of the classification societies, there are three national sets of rules to control navigation in ice-covered waters: Finnish–Swedish, Russian and Canadian. The classification of a vessel is used for insurance and to comply with the international regulations, such as the Safety of Life at Sea (SOLAS) and prevention of pollution. Government-owned vessels are also surveyed for compliance with recognized national and international standards.

The classification societies are responsible for approving the design and supervising the construction of individual vessels to ensure conformity with the standards set by international conventions and by the classification of that vessel. The vessels are subjected to annual and special surveys throughout their lives (Toomey 1994).

The ice classification of a vessel depends on its capability to resist damage while navigating in ice under normal handling conditions. Unfortunately, there are so many classifications by the different societies that it is difficult to establish equivalency among them (Santos-Pedro 1994, Toomey 1994). A limited equivalency among the ice classifications of the various societies is given in the Appendix A of a companion report by Mulherin (1994). At present, an effort is underway to standardize ice classes as international navigation through Arctic routes, such as the Northern Sea Route and the Northwest Passage, becomes more attractive for shipping products between the North Atlantic and the North Pacific (Santos-Pedro 1994). While comparing the ice-strengthening requirements according to the Russian Register Rules and Canadian Arctic Shipping Pollution Prevention Regulations (CASPPR), Karavanov and Glebko (1994) have presented an extensive comparison of the ice loads, section modulus and shear area of frames, and thickness of shell plating. The new CASPPR (1989) regulations call for smaller scantlings and thinner shell plates than those required by Russian Rules because CASPPR allows a certain amount of plastic deformation of the structure under extreme ice loads.

Ice loads and pressures

Compression of ice at low strain rates results in creep deformation with or without micro-cracking. The constitutive relations between stress and strain for creep deformation at low strain rates are well known. At higher strain rates ($>10^{-3}\ s^{-1}$), the ice fails in a brittle manner, resulting in instabilities caused by macro-cracking. The failure mechanism for brittle failure has not been fully understood. Failure loads or pressures also depend on the state of stress, e.g., uniaxial vs. multiaxial. At present, the dependence of compressive failure of ice under multiaxial loading at different strain rates is being studied by researchers all over the world (e.g., Frederking 1977, Richter-Menge et al. 1986, Smith and Schulson 1994, etc.).

There have been attempts made to relate the forces exerted on a ship or a structure by crushing of ice to the uniaxial compressive strength of ice, but these attempts to obtain empirical relationships through the use of many coefficients have not been fruitful. Although much has been known about the forces from flexural failure and compressive failure of ice at low strain rates, the understanding of brittle failure is still incomplete at high rates of loading and in a multiaxial state of stress. Results of small-scale indentation experiments on freshwater ice indicate that brittle failure is activated at

high rates of indentation, resulting in nonsimultaneous contact between the ice and the indentor.

Design values are taken from empirical relations obtained from full-scale measurements of ice pressure. The data on effective pressures obtained from full-scale measurements during ice–ship and ice–structure interactions (Masterson and Frederking 1993) are plotted with respect to contact area in Figure 12, and these data provide empirical values for effective pressure to be used in design.

Materials

Considerable effort has been devoted by classification societies and regulatory authorities to the selection of steel grades suitable for use in the structure of ships that are exposed to very low temperatures. The fracture toughness of steel depends on the operating temperature and on the rate of loading. In Figure 13, the plane strain fracture toughness of two types of steel has been plotted with respect to temperature for three rates of loading.

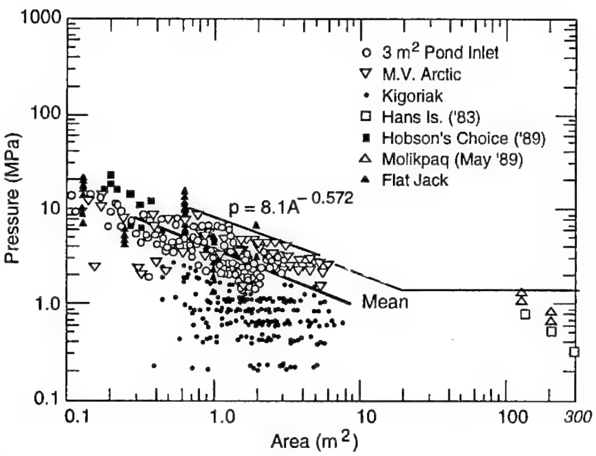


Figure 12. Measured effective pressure vs. contact area (after Masterson and Frederking 1993).

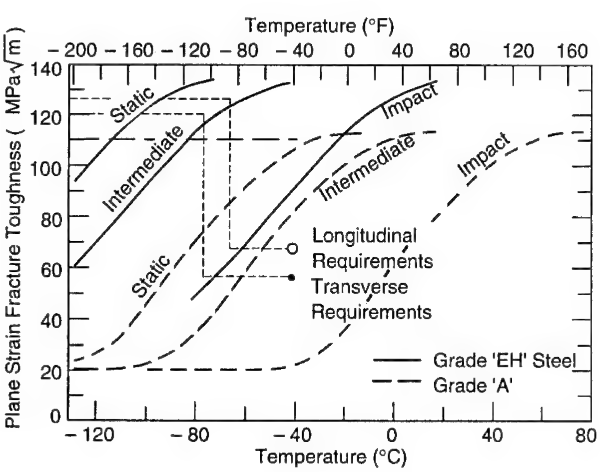


Figure 13. Plane strain fracture toughness vs. temperature for two grades of steel ("A" and "EH") (after Dick et al. 1987).

Steel fractures in a brittle manner, without any warning of impending failure, when the stresses are of sufficient magnitude to propagate a crack from a flaw or small crack in the material. The criterion for crack propagation in linear elastic fracture mechanics is that an existing crack will grow when the stress intensity factor at the crack tip is greater than the fracture toughness of the material. For nonlinear material behavior, the causes for brittle fracture have now been established, and the relationships among the cause of fracture, the toughness of the material, the flaw size and shape, the loading rate of the structure, and the temperature are understood. From this understanding, materials and welding techniques have been developed to increase the reliability of ship structures. It is the consensus of many operators that the steel used in the present generation of polar ships is mostly adequate (Dick et al. 1987).

There are currently two procedures for specifying the type of steel to be used in different parts of a ship: "design by rule" and "design by analysis." Design-by-rule procedures require the designer to consider service temperature and to select steel grades that have adequate notch toughness. Design-by-analysis procedures require the designer to consider the magnitude and the rate of loading that may be applied during the life of a component, and to design that component with adequate reliability according to its importance. The design-by-analysis approach places a large responsibility on the designer, but it may provide a more reliable and economical design than that by the design-by-rule approach.

The midbody region of a ship will experience vibrations excited by shocks at the bow, but the vibratory stresses have much longer rise time than shock-induced stresses, resulting in small chances of initiating a fracture. However, the static stresses from vibrations may be high enough to cause fracture in the primary structure of a ship. Ships have experienced brittle fracture in the midbody region, and because damage in this area is potentially more catastrophic than damage to the bow, materials and welding techniques should prevent both crack initiation and propagation. Because small cracks and defects in a material are inevitable, the material selected must have crack arrest properties to stop crack propagation.

Welding

After selection of steel, welding is the next most important component in the reliability of the structure of ships (Dick et al. 1987). Welds in ships must withstand the corrosive effects of seawater, stresses caused by cargo, icebreaking operations and wave-induced motions. The biggest variable in welding technology is the skill of the welder, especially when working in confined spaces. To determine the reliability of a structure, the designer of a ship must take into consideration the flaws in the material as well as in the welds. The importance of quality control in welding can be assessed from the statistics that 95% of all defects in a structure originate from defects within the welded zone.

The fracture toughness of a weld depends on the method of weld deposition, including the rate, the number of passes, heat input and electrode size. The variations in weld toughness may be larger than those of the parent materials. Caution should be exercised not to degrade the toughness properties of a weld by using large electrodes and fast rates of deposition in the interests of cost saving. Research on reducing the accelerated corrosion of welds is under way in different parts of the world.

Plating

The plating contributes the largest component to the structural weight of most ships and, together with the frames and the stringers, it forms the stiffened panels that resist the loads on a ship (Dick et al. 1987). While the weight of a ship can be reduced by reducing the plate thickness and by increasing the framing, this increases the cost of fabrication.

When a rectangular plate supported by frames on four sides is loaded by uniform pressure that acts perpendicular to its surface, the deflections and the stresses in the plate can be calculated by the small deflection theory of plate bending, as is usually done for structural analysis. This theory ignores the membrane stresses that develop because of large deflections and yielding of the material. As a result of ignoring the membrane action, the load carrying capacity estimated from small deflection theory is small compared to those obtained from large-deflection theories and experiments.

Figure 14 shows plots of load vs. deflection obtained from experimental results and two plastic analyses—one that considers elastic flexure followed by formation of three plastic hinges without any membrane action, and the other that considers only ideal plastic membrane action. The loads in the plots have been made nondimensional with respect to the collapse load predicted by the formation of three hinges without membrane action, and the deflection is made nondimensional with respect to the plate thickness. Figure 14 shows that the curve depicting the experimental load-carrying capacity of a plate is initially close to that predicted by elastic flexure theory for small deflections, and then it approaches that predicted by the plastic membrane action theory for large deflections. This suggests that thick plates form plastic hinges before the membrane action is activated (Ratzlaff and Kennedy 1986).

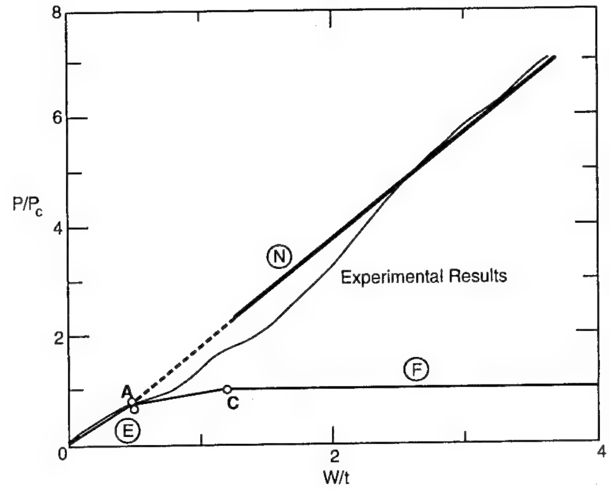


Figure 14. Pressure vs. deflection, showing domains of different behaviors from small to large deflection (after Ratzlaff and Kennedy 1986). Along the vertical axis, the applied pressure P is made nondimensional by P_c, the pressure at which collapse (point C) is assumed to take place by formation of three hinges without membrane action. Along the horizontal axis, the maximum deflection W is made nondimensional by the plate thickness t. The curve labeled E represents elastic flexure with an elastic membrane up to the complete formation of an edge hinge. The curve labeled F represents elastic flexure without membrane action, followed by the formation of the first hinge and then three hinges. The curve labeled N represents ideal membrane action.

Framing

The frames support the shell plates and resist the loads on the shell by bending and shear deformation. Inspection of ice-damaged vessels has revealed that failure takes place consistently in the supporting frames rather than the hull plating (Dick et al. 1987, DesRochers et al. 1994). Frames have several components: the shell plate that acts as a flange, a web, an internal flange (optional), end brackets (optional), tripping brackets (optional) and cutouts (optional).

The proposed CASPPR allow a certain amount of plastic deformation of the structure under extreme ice loads, and they provide factors to account for the post-yield buckling of stiffened structures. DesRochers et al. (1994) compared the stability of flat bars with that of angle sections in a stiffened structure. When a structure is designed for buckling according to linear analysis, flat bars are avoided because angle sections have large moments of inertia to resist bending. However, DesRochers et al. (1994) found that the use of flat bar sections increased the stability of the composite structure beyond the yield point of the material, whereas the structural stability decreased with the use of angle sections as yielding progressed through the frame. The structure of the Canadian icebreaking cargo ship *Arctic* has been redesigned according to CASPPR to carry full ice loads without failure.

The Swedish icebreaker *Oden* is the first icebreaker designed according to the technology behind the proposed CASPPR, making it possible to use a large frame spacing of 850 mm instead of the normal 400 mm (Johansson et al. 1994). This has resulted in considerable cost savings in construction. After the voyage of *Oden* to the North Pole, inspection of the structural damage revealed some indents in the shell plating between frame stations 30 and 76 on both sides, and some deformation in the side and bottom frames (flange, web and bracket), but this damage was not serious. The damaged frames were reinforced, but the indents in the steel plates were left as they were (Backman 1994).

PROPULSION SYSTEM

The major components of the propulsion system of an icebreaking vessel, or any ship, are the propellers, shafts, transmission systems and prime movers. The number of propellers varies between one and three. Developments in propulsion systems that have taken place during the last four to five decades are reflected in those of existing icebreakers and icebreaking cargo ships, and these become apparent in the plot of shaft power vs. the year of construction (Fig. 15). Some of the special features of propulsion systems, such as controllable-pitch propellers and mechanical transmissions, nozzles and various electrical transmissions, have been highlighted in Figure 15.

The dc–dc electrical transmission has been commonly used since its introduction on the Swedish icebreaker *Ymer* in 1933. Although this system is still being used on many icebreakers, new mechanical and electrical transmissions have been introduced on newer icebreakers and icebreaking cargo ships. Since 1966, the number of ships with controllable-pitch propellers and mechanical transmissions is steadily increasing. The Russian LASH vessel *Sevmorput*, delivered in 1986, placed all of its propulsion power on one shaft using a controllable-pitch propeller and mechanical transmission, thus doubling the power transmitted per shaft from 16.65 to 29.42 MW (Fig. 15b).

One of the main reasons to use direct mechanical transmission is to cut down the losses in transmission. Since 1978, propeller nozzles have been fitted to icebreakers to increase thrust and to prevent propeller damage by reducing ice ingestion. Nozzles have been installed on most of the Beaufort Sea ice management–supply vessels, whereas *Polar Sea* and *Polar Star* have operated in ice without nozzles since 1976. Recently, azimuth-mounted propulsion units have been installed on the Finnish icebreakers *Finnica* and *Nordica* and it is

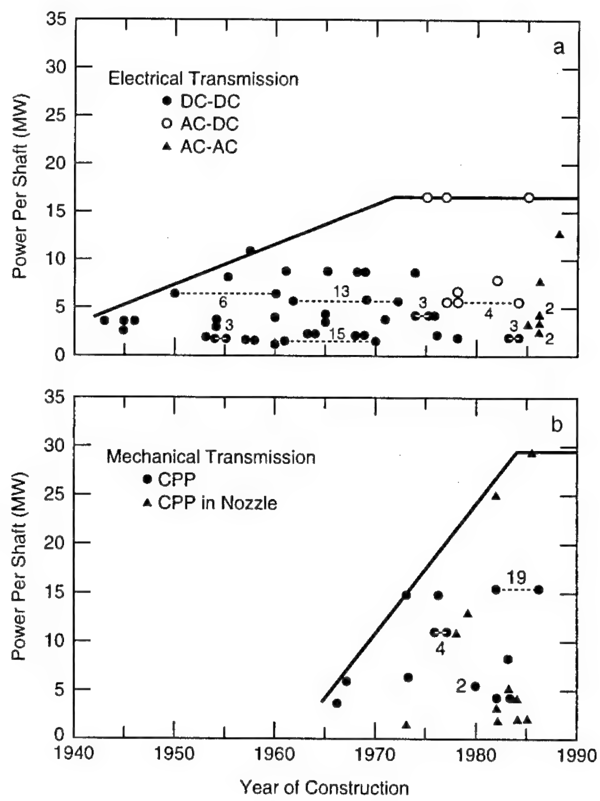


Figure 15. Shaft power vs. year of construction for icebreaking ships: (a) electrical transmission system, and (b) mechanical transmission system (after Dick and Laframboise 1989).

likely that this system will be used in future ships, because it offers good maneuverability in broken and intact ice.

The selection of a suitable propulsion system is based on the intended functions of an icebreaking vessel. The requirements of a propulsion system are:

1. Reliability of full power on demand to navigate safely in the Arctic.
2. Flexibility of operating efficiently and economically in open water as well as in heavy ice at a range of power levels.
3. Maneuverability to allow rapid change of load, speed and power.
4. High power-to-weight ratio to deliver the required power, with machines as compact and light as possible.

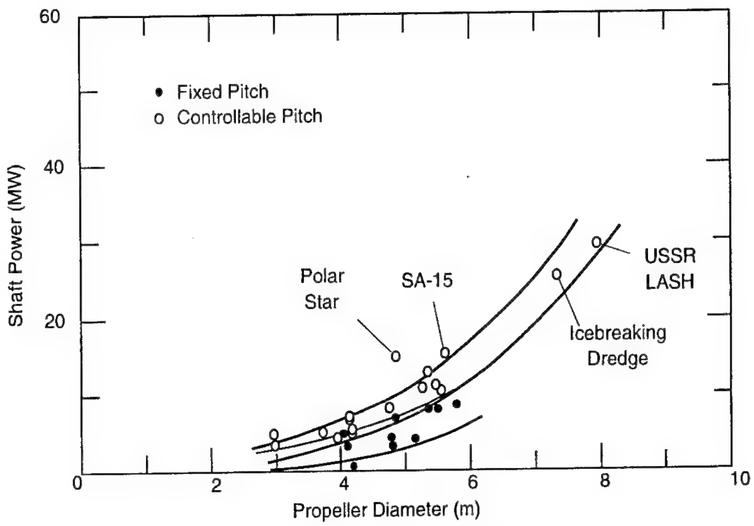


Figure 16. Shaft power vs. propeller diameter for icebreaking ships (after Dick and Laframboise 1989).

While many combinations of prime movers, transmission systems and propellers may be proposed for a given ship, very few particular systems would fit a given mission profile (Dick et al. 1987). Ships requiring a large range of power can be fitted with multiple engines or combined-system installations, which permit the numbers of engines to be run according to the power requirements of various ice conditions, to achieve the best combination of fuel efficiency and performance. In the following sections, a brief discussion is given of each of the main components of a propulsion system.

Propellers

Both fixed-pitch and controllable-pitch propellers have been installed on polar ships. Fixed-pitch propellers have been used for many years, and these are still being installed on most icebreaking ships. However, controllable-pitch propellers have been used on polar ships with increasing frequency since 1966 (Dick and Laframboise 1989). A plot of shaft power versus propeller diameter is shown in Figure 16, where fixed-pitch and controllable-pitch propellers have been identified. The azimuth thruster units installed on the Finnish icebreakers *Finnica* and *Nordica* have fixed-pitch propellers in a nozzle.

The selection of propeller type depends on the propulsion system used. Nonreversing transmission systems, such as diesel–geared or gas turbine–geared, may use controllable-pitch propellers to obtain astern thrust and to ease over-torque requirements. Reversing systems, such as any of the electrical systems, may used fixed-pitch propellers because over-torque does not affect an electrical system.

The design requirements of a propeller depend on the mission profile of a vessel. The aspects influencing the design of a propeller are (Dick et al. 1987):

1. Loads and strength requirements.
2. Selection of material.
3. Effects of nozzles.

There are two types of interactions between ice and propellers: ice milling and ice impact. Ice milling takes place when an ice block is large or is trapped between the hull and the propeller. During an instance of milling, ice is either crushed or sheared by the blades, and the loads can be damagingly high. Ice impact is caused by small-size ice pieces that are accelerated through a propeller or thrown out radially and pushed around the edge of the propeller disk. The loads from ice impact are relatively moderate, but it happens more frequently.

For propellers in a nozzle, the chances of ice milling are small, and the magnitude of the loads generated are also small in comparison to those for open propellers. The factors that influence the ice loading on a propeller have been identified, but the ability to determine the ice milling–impact loads is not well developed because of the complex interaction between ice and propellers. The

design of an ice-strengthened propeller must meet the dimensions and the strength requirements of the classification societies.

The material used for the propeller blades of polar ships must have high stress and impact resistance qualities. Stainless steel and bronze are commonly used for ice-strengthened propeller blades. Because stainless steel has a higher erosion resistance and higher ultimate and yield strengths than does bronze, stainless steel propellers have a slender and efficient blade profile. Most of the existing bronze controllable-pitch propellers are operating in nozzles, whereas most stainless steel controllable-pitch propellers fitted to icebreakers are open propellers. For example, bronze has been selected for the propellers of recent Canadian icebreakers, and the open propellers of the U.S. icebreakers *Polar Star* and *Polar Sea* are made of stainless steel.

Propeller nozzles are used to increase the thrust over a range of ship speed, and to protect the propeller from ice. Thus, the nozzles have an indirect influence on the design of a propeller by reducing the load levels and thereby reducing the strength requirements. Ships equipped with nozzles, e.g., *Kigoriak* and *Arctic*, have operated successfully in ice with very few problems. Some of the shallow-draft vessels, however, have occasionally experienced clogging of their nozzles in rubbled or ridged ice. Nozzles have been installed on the azimuth-mounted propellers of *Finnica* and *Nordica*, and these are being considered for future high-powered ships.

Shafting

For large icebreaking ships, the diameters of propeller shafts are large because of high power and high torque requirements. The range of diameters of the shafts installed in existing icebreakers is from 380 mm in *Polar Stern* to 980 mm in the Russian SA15 cargo ships. The basis for designing shaft diameter is that the propeller blade should fail before the shafting. The method to calculate the shaft diameter depends on the modulus of the propeller section and on the ratio of the ultimate strength of the propeller blade material to the yield strength of the shaft material. The requirements of hydrodynamic torque and ice-induced torque are specified by the classification societies. Shafts are generally made of forged carbon steel, although in some cases low alloy steel forgings are also used. There is considerable saving in weight when high-strength steel is used.

One of the major problems found with large vessels is the misalignment of the shaft bearings. The sources of the misalignment problem are (Dick et al. 1987):

1. Deflections in the hull.
2. Eccentric thrust on the propellers, which causes bending moments in the shaft.
3. Insufficient axial and radial bearing flexibility.
4. Changes in the height of bearings, gear case or the engine because of thermal expansion.

Dick et al. (1987) have discussed other elements of the shaft line components, such as couplings, seals and bearings.

Mechanical transmission components

The operating speed of steam reciprocating engines and slow-speed diesel engines is low enough that the power can be transmitted directly through a shaft between the engine and a propeller. This is the most efficient form of transmitting power to a propeller, because the only losses incurred are at the bearings. However, most prime movers, such as medium-speed diesel and steam and gas turbines, have an output speed that is too high to obtain the best propeller efficiency. A speed-reducing transmission must be used to deliver power to the propellers at the optimum speed.

As shown in Figure 15b, many icebreakers and icebreaking cargo vessels have been fitted with mechanical transmission of power since 1966. Most of these vessels are driven by one or more medium-speed diesel engines and a set of single-reduction gears, except the Russian LASH, which is driven by a steam turbine. A clutch or fluid coupling is used between an engine and a gear system. In a few icebreakers, flywheels have also been used to smooth out the transient, ice-induced torque.

The gearboxes that are installed on polar ships are within the experience of the manufacturers. The largest gearboxes installed on any icebreaker are those on the U.S. icebreakers *Polar Sea* and *Polar Star*, which are powered by combined gas turbine and diesel-electric systems. The Russian SA15 cargo ships have been fitted with large gearboxes with twin inputs, each delivering 7.5 MW, and connected through fluid couplings to limit overload torque.

Electrical transmission systems

Four types of electrical transmission systems are available for polar ships. These systems are listed according to their chronological order of develop-

ment: dc–dc, ac–ac, ac–dc, and ac–FFC–ac. An ac system is preferred because of its light weight and higher efficiency. The problems of commutation in dc systems are not present in ac systems.

The advantages of an electrical transmission over a mechanical one are that the characteristic of the drive can be exactly matched with the mission profile of a ship, and that the total power for the ship can be divided among a number of engines. There is flexibility in the placement of generators in a ship. An electrical system also isolates the prime mover from the overload torque caused by ice loads on the propellers. The disadvantages of an electrical transmission system are the higher costs, greater weight and larger space requirements.

With medium-speed diesel engines as prime movers, the dc–dc system is most commonly used in icebreakers. The maximum speed of a dc generator must be less than 100 rpm owing to the limited capacity of the commutator brushes to transmit current. The advantages of a dc system are its simplicity, ease of control, good torque characteristics (especially at low speed) and lower cost than other electrical systems. In comparison to mechanical transmission systems, the disadvantages of this system are its higher cost, greater weight and volume, lower transmission efficiency (about 85%) and a relatively high requirement for manpower.

The ac–dc system combines the advantages of ac generators with the precise speed control of dc motors. The generated power, in three-phase alternating current, is converted with low losses to direct current by the use of thyristors, which were developed in the 1960s.

The ac–ac propulsion system is based on synchronous motors. The speed is changed by changing the speed of the prime mover. It is the simplest and least expensive. This system, while perhaps being the economical choice for open water ships, is not suitable for icebreaking ships. The generator and the motor may fall out of synchronization when the propellers are subjected to large ice loads. Other disadvantages of this system are the low torque at start up and the excitation of resonant vibrations.

The ac–ac system with Full Frequency Control (FFC), or a cyclo-converter, is the most suitable but also the most expensive ac–ac system. It has been used in the Finnish icebreakers *Otso*, *Finnica* and *Nordica*, in the Russian *Taymyr*-class icebreakers and in Canadian light icebreakers. By employing cyclo-converters, the motors can be precisely and steplessly controlled by a highly reliable control setup. Its advantages are the availability of full torque over the entire range of speed, no loss of synchronization, operation of the prime mover at its optimum speed, and the availability of power for auxiliary systems from the main generators. Its main disadvantages are the high capital cost, high volume and weight, and relatively poor overall transmission efficiency of 90–92% (estimated), although the transmission efficiency of ac–FFC–ac systems is higher than that for ac–dc and dc–dc systems.

Azimuth propulsion drive

Azimuth propulsion drives have been installed on different types of vessels, such as icebreakers, cargo ships, ferries, cruise ships, etc. One of the *Lunni* series tankers, *Uikku*, was converted in 1993 to accommodate 11.4-MW azimuth propulsion drives (one of the world's most powerful units), replacing the original medium-speed diesel, gearing, shafting and controllable-pitch propellers. Installation of these units on the multipurpose icebreakers *Fennica* and *Nordica* has produced excellent icebreaking and maneuvering capabilities. With their advanced hulls (designed to give excellent seakeeping in open waters [Fig. 9]), these vessels can make continuous progress through 1.8-m-thick ice. Their icebreaking capabilities are also very good when they are moving astern. The azimuth thruster units allow these ships to turn on the spot in ice conditions. Lohi et al. (1994) give the results of full-scale ice tests with *Fennica* during her trials in the Baltic.

There are two commercial azimuth propulsion systems available—Aquamaster and Azipod. In an Azipod unit, an ac electrical motor is located inside the pod, whereas the motor is located above the azimuth thruster units in Aquamaster drives. The motor, controlled by a frequency converter, directly drives a fixed-pitch propeller, which is either open or placed in a nozzle. These drives azimuthally move 360° and supply full power in all directions.

Figure 17 shows the difference between conventional diesel–mechanical and azimuth propulsion systems on an arctic tanker. The azimuth system has the following advantages:

1. Gives excellent dynamic performance and maneuvering characteristics.
2. Eliminates the need for long shaft lines, transverse stern thrusters, controllable-pitch propellers and reduction gears.
3. Allows new ways for designing machinery and cargo spaces.

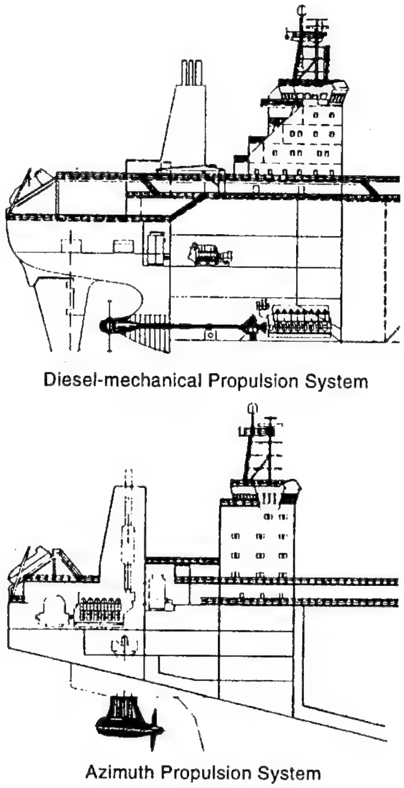


Figure 17. Differences between diesel-mechanical and azimuth installations (after Kværner Masa-Yards and ABB, no date).

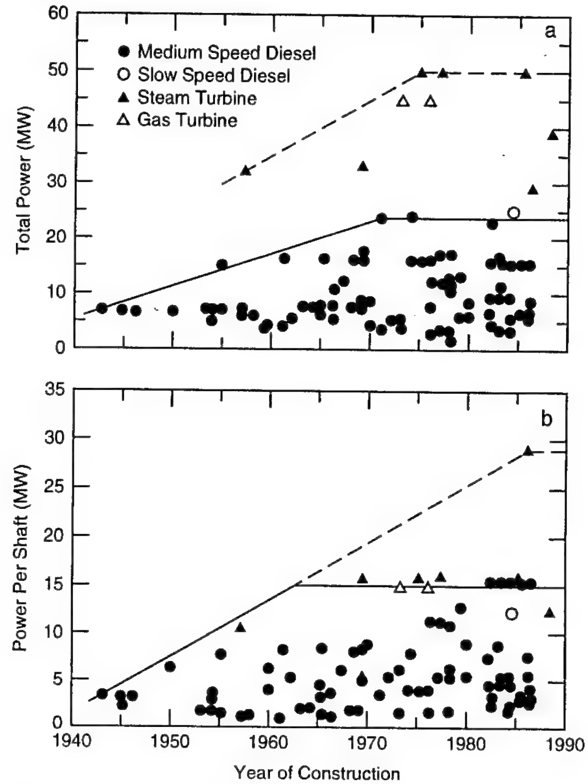


Figure 18. Prime movers installed on icebreaking ships: (a) total power vs. year of construction, and (b) power per shaft vs. year of construction (after Dick and Laframboise 1989).

4. Reduces noise and vibrations.
5. Provides operational flexibility, resulting in lower fuel consumption, reduced maintenance costs, fewer exhaust emissions and adequate redundancy with less installed power.

In late 1990, the propulsion system of the Finnish waterway service vessel *Seili* was converted from diesel-mechanical propulsion to azimuth (Azipod) propulsion. The performance of this vessel was tested in 65-cm-thick, level ice in the Gulf of Bothnia. Laukia (1993) reported that, besides good maneuverability and icebreaking capability in level ice and first-year pressure ridges, the vessel broke ice better when moving astern than while moving ahead. There are unconfirmed reports that new vessels with two types of hulls at each end are on the drawing boards of shipyards: a smooth bow for moving forward in open-water, and an icebreaking stern for moving astern through first-year ice in sheltered areas.

Prime movers

The characteristics of an ideal prime mover for an icebreaking ship are reliability, flexibility, maneuverability, robustness and over-torque capability (Dick and Laframboise 1989). These characteristics have been discussed earlier for the propulsion system. The prime movers used currently in polar ships do not have all these characteristics, but in combination with a suitable transmission, the overall propulsion system can approach the above-mentioned ideal characteristics.

Figure 18 shows two plots of total installed power and power per shaft versus the year of construction. In Figure 18 different types of prime movers have been identified. Each type is briefly discussed in the following.

Gas turbines

Only two icebreakers, the USCG *Polar Star* and *Polar Sea*, are fitted with gas turbines. Each ship has three aero-engine derivative gas turbines, each driving a controllable-pitch propeller through a gearbox. These turbines are used only for heavy icebreaking, and a medium-speed diesel-electric propulsion system is used for cruising and light icebreaking. The Canadian icebreaker *Norman McLeod Rogers* was initially fitted with two indus-

trial turbines, but they were replaced with medium-speed diesel engines because of high fuel consumption.

Turbines are unidirectional engines, and the astern operations must be provided by the transmission, usually through an electrical system, a reversing gear or a controllable-pitch propeller. The advantages of gas turbines over other prime movers are their high power-to-weight ratio and their compactness. Their main disadvantages are the high fuel consumption and maintenance requirements.

Steam turbines

Only the Russian nuclear-fueled icebreakers and icebreaking cargo ships are fitted with modern steam turbines. The Canadian icebreaker *Louis S. St. Laurent* was fitted with a steam-turbine–electric system, but a diesel-electric system was installed during the ship's major reconstruction program, completed in 1993. The efficiency of a steam turbine is about 20%, compared to 50% for modern marine diesel engines (Dick et al. 1987). Similar to gas turbines, steam turbines are unidirectional engines, and astern operations must be handled by the transmission. Turbines can operate at any power level, but the fuel efficiency is poor at reduced power levels.

Medium-speed diesel engines

Medium-speed diesel engines have most commonly been used as prime movers for the propulsion of polar ships because of their compactness, light weight, fuel efficiency and good reliability (Dick and Laframboise 1989). Their disadvantage for use as prime movers is their lack of significant over-torque capacity. However, this shortcoming is overcome by using an electrical transmission, which damps out the high torque transients and stops them from being transmitted to the engine. A few icebreakers are fitted with these engines driving controllable-pitch propellers through gears. Some of the direct drive systems consist of fluid couplings to prevent engine stall under the most severe propeller overloads.

In the past 15 years, medium-speed diesel engines have undergone developments that have allowed them to have better fuel economy, burn heavier grades of fuel, increase routine maintenance intervals and increase the power per cylinder. Some of the largest engines of this type can generate about 22 MW at 400 rpm in 18 cylinders arranged in a vee form (Dick et al. 1987). The engines operate in one direction, and separate provisions, in the form of controllable-pitch propellers or reversing gears, are used for astern operations. Typical specific fuel consumption of the engines is between 170 and 200 g/kWh, and the consumption of lubricating oil is between 1.5 and 3 g/kWh. Most medium-speed diesel engines for icebreakers use turbochargers to improve their fuel efficiency in open water. Diesel engines are basically constant torque machines in the 50–100% range of speed. At a given load, torque may exceed the rated capacity by about 10%. The flexibility of diesel engines is acceptable because they can operate between 25 and 35% of their rated speed, depending upon the characteristics of a particular engine. It is expected that medium-speed diesel engines will continue to be the preferred prime movers for polar ships of all sizes in the near future (Dick et al. 1987).

Slow-speed diesel engines

The Russian LASH ship *Alexey Kosygin* is the only polar ship fitted with two slow-speed diesel engines, each delivering 13.4 MW to directly drive fixed-pitch propellers (Dick et al. 1987). This type of engine was specifically developed for ship propulsion. They operate on the two-stroke cycle, are reversible, and are directly coupled to propellers, mostly of the fixed-pitch type. The range of their rotational speed is between 60 and 225 rpm. The range of cylinder bore diameter is from 250 to 900 mm. The maximum power per cylinder is about 3.7 MW. This type of engine is large and heavy, and it can only be fitted to vessels that can provide a large engine room and carry the extra weight: bulk cargo ships, oil tankers and container ships. Ferries, Ro/Ro ships and barge carriers have limited head room and are generally fitted with medium-speed diesel engines. These engines are not suitable for polar ships because of their poor maneuverability and flexibility.

Developments in the last 15 years include the use of constant pressure turbocharger technology and the adoption of extra-long strokes. This has enabled slower propeller speeds without the use of gears, resulting in higher propulsion efficiency in large bulk carriers and oil tankers. The specific fuel consumption of these engines is below 160 g/kWh for large economical engines, and about 175 g/kWh for small engines.

Combined prime movers

The reason for combining two different prime movers in a ship is to improve the overall fuel economy. This is done by either recovering the

waste heat and converting it to mechanical work, or by operating each prime mover according to load demands to obtain better fuel economy. The first option has not been used in icebreakers so far.

The USCG icebreakers *Polar Sea* and *Polar Star* are the only polar vessels fitted with two types of prime movers. In these ships, there are three gas turbines (total 45 MW or 60,000 shp) and three diesel-electric propulsion systems (total 13.4 MW or 18,000 shp) for each of the three controllable-pitch propellers. Each shaft can be turned either by the diesel-electric or the gas turbine power plant. Either one or two 2.24-MW (3000-shp) diesel-electric drive units, or a single 15-MW (20,000-shp) gas turbine, can be used to drive each shaft. For example, diesel engines could supply power to the wing shafts, while a gas turbine could turn the center shaft. Gas turbines are used for heavy icebreaking, whereas the diesels are used for cruising and light icebreaking. This is a good example of combining two different systems to meet widely differing load demands for the sake of fuel economy.

AUXILIARY SYSTEMS

There have been other developments to improve the performance of polar ships besides those in propulsion systems and hull shapes, such as the use of low-friction coatings on the hull, air-bubblers to lubricate the ice/ship interface, air-bubbler–water-injection systems, and the water-deluge (or wash) system to pump a large volume of water on the ice ahead of the vessel. These improvements have also contributed to increase the icebreaking capability of polar ships beyond the limit for which they were designed. A brief account of each auxiliary system follows.

Low-friction hull coating

Depending on the age of a vessel, the coefficient of friction between ice and unpainted hull plating can be in the range of 0.2 to 0.3, which is high in comparison to the friction coefficient in the range of 0.05 to 0.17 between ice and a low-friction coating. As discussed later, the factor to account for the friction of old steel in the expression for ice resistance of an icebreaker is twice that for Inerta-coated steel plates (Keinonen et al. 1991).

Prior to the 1970s, there was no suitable coating available that could withstand interaction with ice. Only anti-fouling paint was applied to the hulls to minimize biological growth on the hull surface, and this would wear off during first few days of icebreaking. In the early 1970s, the importance of hull–ice friction on the ice resistance was demonstrated through full-scale and laboratory tests. A measure of the force attributable to static friction acting on a hull can be obtained by gradually increasing the level of power to initiate forward motion of a ship that was stopped in ice and then measuring the steady-state velocity at that same power level. For ships having uncoated hulls, this power level corresponds to a 3-knot (1.5-m/s) speed of advance, whereas for a ship with low-friction coating, the initiating power levels are equivalent to a speed of 0.5 knots (0.26 m/s) (Voelker 1990). The power required for an icebreaker with a low-friction coating to become unstuck is much lower than that for ships without any coating.

Mäkinen et al. (1994) have given an historical account of the development of low-friction coatings in Finland, where the first effective hull coatings were developed by Wärtsilä Shipyard (now Kværner Masa-Yards). Liukkonen (1992) developed a theoretical understanding of hull–ice friction and found a functional relationship between the coefficient of friction and the normal force. This functional relationship was verified by full-scale measurements of normal and frictional forces with the help of instrumented panels installed in the bow and the sides of icebreakers.

Mäkinen et al. (1994) have listed the requirements of a good low-friction coating. A few of these are reasonable cost, high bond strength with and good corrosion protection for the base material, and resistance to all of the following: wear, high normal pressure, low temperatures and changes in temperature. Tests were conducted on many different coatings; Inerta 160 and stainless steel were selected for full-scale testing and further development. Another coating by the name of Zebron was also found to be suitable, but its use has decreased with time, perhaps because of lower resistance to wear.

Inerta 160 has been applied to hundreds of ships currently in service (Mäkinen et al. 1994). It is applied with a two-component spray gun, which has heating equipment to keep the temperature of the paint between 40 to 50°C. Two problems associated with the application of Inerta 160 were corrosion of cast iron propellers and corrosion of hull surfaces. These problems were corrected by using stainless steel propellers and cathodic corrosion protection.

An important property of a coating is to withstand the deformation of the base material. In the

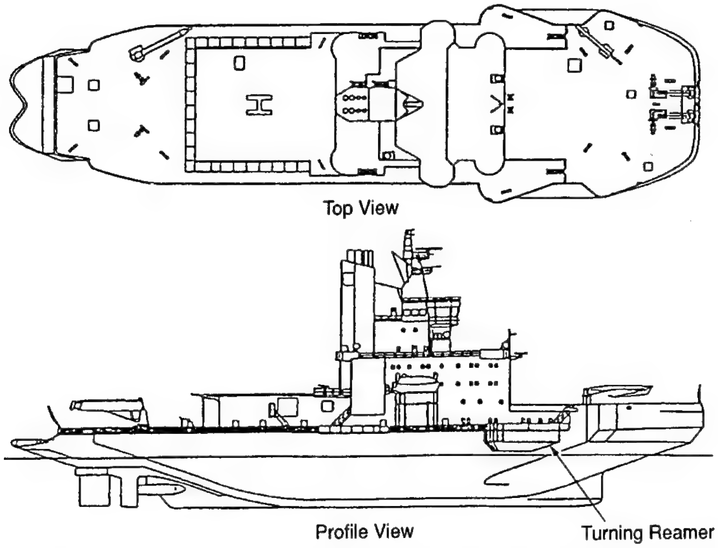


Figure 19. Outboard profile and topside deck plan of the Swedish icebreaker Oden.

case of Inerta 160, the wear-off starts at the cracks caused by the deformation of the shell plating at the edges of the ship's frames. The wear-off is intensified in heavily loaded areas, such as the ice belt in the ship's forebody, and during operations in heavy ice and especially in the presence of soil or sand mixed in ice. To correct this deficiency in Inerta 160, stainless-steel-coated surfaces, though expensive, were developed because of their high wear resistance and low-friction properties. Cathodic protection systems were developed to reduce the corrosion risks before compound steels with stainless steel claddings were installed in the ice belt regions on two *Otso*-class icebreakers for testing. Later, stainless steel compound plates were installed on the Russian icebreaker *Kapitan Nikolayev* and the Finnish icebreakers *Finnica* and *Nordica* with very favorable results.

The cost of applying Inerta 160 and installing stainless steel compound plates is, respectively, about 2 and 40 times the cost of applying conventional paint (Mäkinen et al. 1994). However, the extra cost of applying Inerta 160 may be offset by longer periods (4–5 years vs. 1 year) between reapplications of the coating, while compound steel does not require any repair or reapplication. There have been no corrosion problems with compound plate; however, the cathodic protection systems must be permanently activated, even during the summer. Investigations are currently underway to use copper-nickel compound plates as an alternative to stainless steel compound plates (Mäkinen et al. 1994).

Heeling system

In earlier times, the crews of cargo ships that were stuck in ice found that lifting a heavy weight by a crane and swinging it sideways helped to free the ship. This experience led the designers of icebreakers to install heeling tanks on each side of a ship and to provide for pumping large amounts of water back and forth between the tanks. The continuous rolling motion of a ship facilitates its progress in ice with less power.

Now most operators consider the heeling system important for improved icebreaking and maneuvering. Almost all Baltic icebreakers have heeling tanks. The Swedish icebreaker *Oden* was fitted with a fast heeling system that allows full heeling in 15 seconds (Backman 1994). This has enabled *Oden* to make continuous progress in heavy ridges. *Oden* is also fitted with turning reamers located above the ice surface on each side just aft of the bow (Fig. 19), and when the ship is heeled over, one reamer comes in contact with ice to help the ship to turn sharply into the heel (Johansson et al. 1994). Thus, a heeling system in combination with the turning reamers has improved the maneuverability of *Oden* by decreasing the turning radius. With improved maneuverability, polar ships are often able to make progress in thicker ice than they have been designed for, by finding a path of least resistance through the weaknesses in an ice cover. This is demonstrated by the successful voyage of *Oden* in 1991 with the German icebreaker *Polarstern* to the North Pole.

Air-bubbler system

An air-bubbler system releases large volumes of air through nozzles into the water below the ice in the bow and midbody portions of a ship. When the air rises to the surface, it brings water with it between the ice and the hull, thus reducing friction between them.

This system was first introduced on the Finnish icebreaking ferry *Finncarrier* in 1969 (Johansson et al. 1994). It has since been installed on vessels with conventional bows, such as the *Lunni* class of icebreaking tankers, the Canadian icebreaking cargo ship *Arctic*, and the Russian SA15's. The results of full-scale trials indicate that a bubbler system may help in reducing friction only in the low-speed range (less than 2 m/s or 4 knots). There

is no measurable benefit of an air-bubbler system on ships with unconventional bows. Captains of Bay-class Great Lakes icebreakers report that air bubblers are very useful for docking or leaving the docks under ice conditions.

To assess the effectiveness of hull lubrication by an air-bubbler system, the ratio of shaft power saved at a given speed in level ice to the power required to operate the system is computed. If this ratio is more than one, there is a net power saving in operating the system. According to the data compiled by Keinonen et al. (1991), this ratio for the air-bubbler system of hull lubrication is generally less than, or in some cases barely greater than, one. The reason for such low efficiency is that lubrication is not provided around the bow waterline, where it would be most effective.

Air-bubbler–water injection system

This system, installed on the German icebreaker *Polarstern*, injects air into the water being pumped to nozzles at the sides of the ship below the ice. Air–water jets have also been installed below the water on the Canadian icebreaker *Ikaluk* and the newly converted Russian icebreaker *Mudyug*. The ratio of power saved to the power expended is about one (Keinonen et al. 1991).

Water-deluge system

Recent developments, such as the water-deluge system and low-friction epoxy paint, have allowed the use of unconventional bows on sea-going vessels (Johansson et al. 1994). A water-deluge system throws several tons of water every second on top of the ice ahead of the bow. This not only reduces friction between the ice and the hull but also submerges the broken ice pieces to help them move down under the hull. This was first installed on the Canadian icebreaker *Canmar Kigoriak*, which was fitted with a blunt spoon-shaped bow, to solve the ice pushing problem experienced with unconventional bows in the late nineteenth century. One time, when the water-deluge system was frozen solid, the *Kigoriak* could not make good progress through a broken ice cover because of the ice-pushing problem. With the water-deluge system operating perfectly a few days later, she was able to make good progress in this same broken ice field (Johansson et al. 1994).

According to the data compiled by Keinonen et al. (1991), the power saved as a result of operating a water-deluge system is much greater than the power expended. These data were collected for the *Canmar Kigoriak* during icebreaking with a bare hull and also with an epoxy-coated hull.

On the Canadian icebreaking supply vessel *Robert Lemeur*, this system has been effective in reducing the resistance by 20–30% over the entire speed range (Dick and Laframboise 1989). On the Swedish icebreaker *Oden*, the water-deluge system has been upgraded to act as a bow thruster by directing the flow to one side of the ship. With a control system and a modified nozzle design, it is possible to obtain a side force of 0.1 MN at the forward tip of the ship.

POWER AND PERFORMANCE

As expected, installed power increases with ship size as represented by ship beam. The power-versus-beam plot of the data on existing polar ships (Fig. 20) shows a trend of increasing power as a function of beam. Except for a few data points, there appears to be a well-defined relationship between power and beam.

Using information on the performance of existing polar ships in ice, Dick and Laframboise (1989) plotted the bollard pull/beam vs. the ice thickness an icebreaker is capable of breaking at a speed of about 1 m/s or 2 knots (Fig. 21). For comparison, the data are normalized on performance for a speed of 2 knots. There appears to be a well-defined minimum performance. For a particular bollard pull/beam, the range of ice thickness above a minimum performance value represents an improvement in icebreaking capability of the hull shape. Figure 21 shows that the most recent ships have more efficient hull forms.

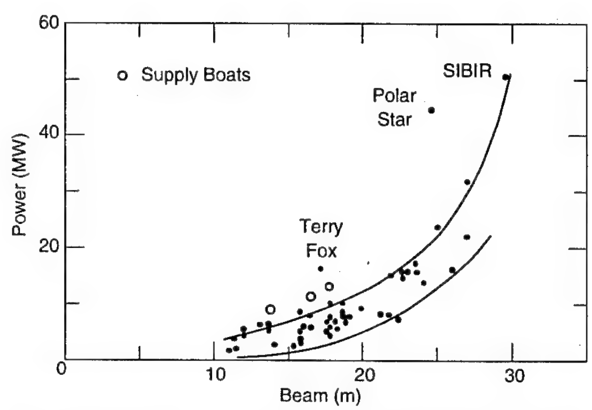


Figure 20. Power vs. beam for icebreakers (after Dick and Laframboise 1989).

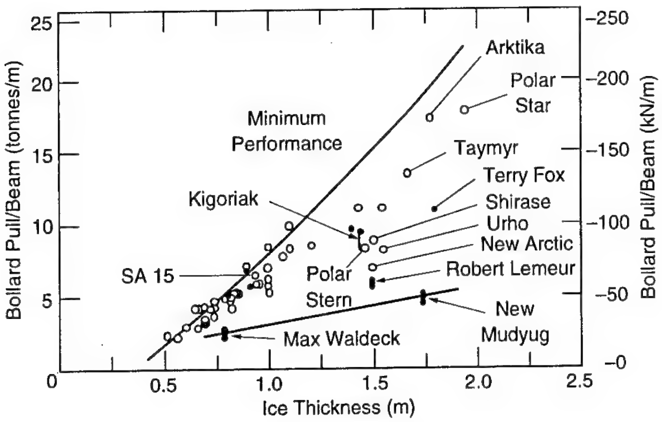


Figure 21. Icebreaking performance: bollard pull/beam vs. ice thickness. Bollard pull is measured or calculated; data are adjusted for a speed of 2 knots (after Dick and Laframboise 1989).

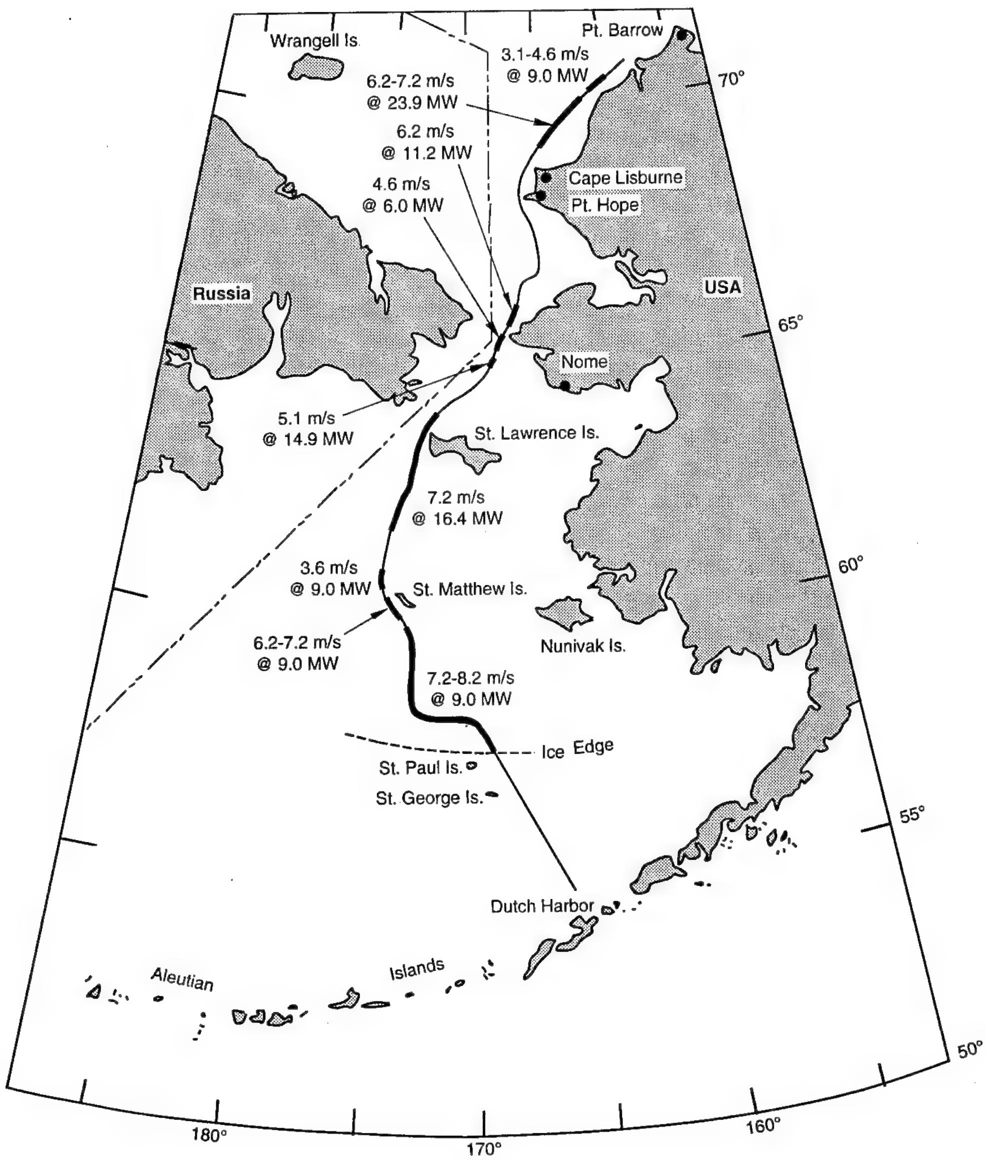


Figure 22. Speeds and power levels of U.S. icebreaker Polar Sea *during her transit from 23 March to 4 April 1983 (after Voelker 1991).*

Table 2. Estimates of daily fuel consumption for a *Polar*-class icebreaker.

Ship status	*Fuel consumption rate* (gallons/day)	(tons/day)*
Stationary—systems providing only normal hotel services	4,000	12
Open water transit (three propulsion diesel)	14,000	42
Icebreaking (six propulsion diesel)	25,000	75
Icebreaking (diesel on wing shafts, gas turbine on center shaft)	35,000	105
Icebreaking (three gas turbines)	60,000	180

* Relation used for conversion: 1000 gallons/day ≈ 3 tons/day.

Fuel consumption rates

The fuel consumption rates of medium-speed and slow-speed diesel engines have been mentioned earlier. These rates may have been obtained for open water conditions. Data on the actual fuel consumption of icebreakers working in ice are very scarce.

Voelker (1990) has summarized the mean fuel consumption rates of 16 *Polar*-class ship deployments to the Alaskan Arctic (Table 2). The rate of fuel consumed depends on the ship's activity and the power plant being used. The *Polar Sea* and *Polar Star* can each generate up to 13.4 MW (18,000 shp) using diesel-electric propulsion systems. Alternatively, they can generate up to 45 MW (60,000 shp) by engaging their gas-turbine power plants. In Figure 22, Voelker's route map shows the sustained speeds for various power outputs during a midwinter expedition through the Bering Sea and into the Alaskan Chukchi Sea. Figure 23 identifies sections of the route where ramming of the ice was required to make headway. The number of rams and the average shaft power used are also given in Figure 23.

According to the brochures of the Murmansk Shipping Company, the rates of fuel consumption of three classes of ships (*Norilsk, Mikhail Strekalovskiy* and *Dimitriy Donskoy*) are listed in Table 3.

Performance prediction

Keinonen et al. (1991) compared the performance of 18 major icebreakers of different sizes and types to establish methods of expressing and estimating their performance in terms of ship design features and parameters. The data were obtained from full-scale trials of icebreakers in different geographical areas as well as in different ice

Table 3. Fuel consumption rates of a few Russian ships according to the information given in the brochures of the Murmansk Shipping Company.

Ship	*Type of fuel or oil*	*Storage capacity (tons)*	*Daily consumption rate (tons/day)* *Underway*	*In port* *Cargo operation*	*No cargo operation*
SA15's *Noril'sk* Class	Diesel oil	783	2.0	2.0	1.0
	High viscosity fuel	3743	76.0	7.0	3.0
	Lubricating oil	185	0.6	0.1	0.1
Mikhail Strekalovskiy Class	Diesel oil	329	5.0	2.5	2.5
	High viscosity fuel	1348	43.1	7.3	7.3
	Lubricating oil	52	0.3	—	—
Dimitriy Donskoy Class	Diesel oil	329	5.0	2.5	2.5
	High viscosity fuel	1348	43.1	7.3	7.3
	Lubricating oil	52	0.3	—	—

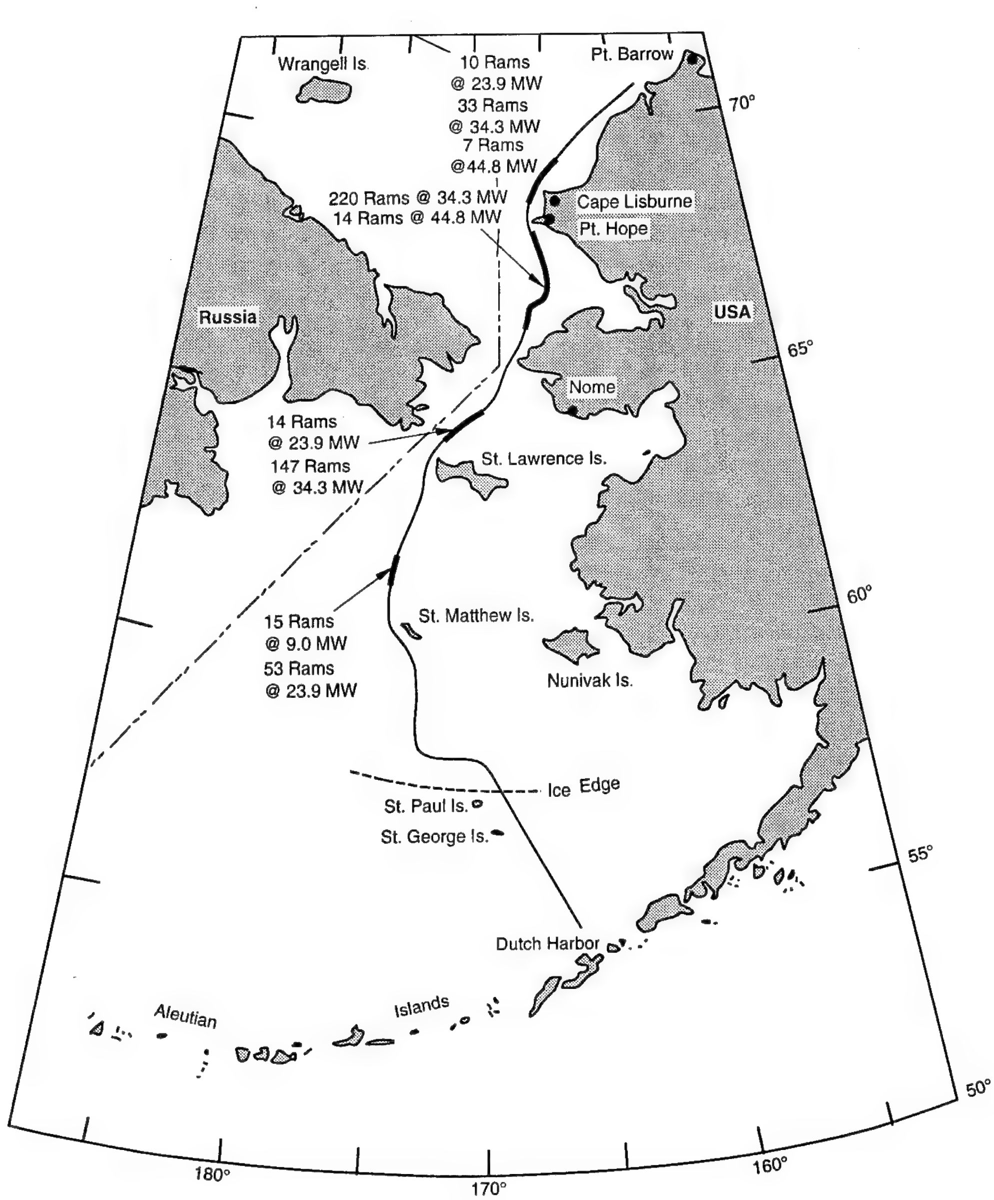


Figure 23. Number of ramming operations during the transit of U.S. icebreaker Polar Sea *from 23 March to 4 April 1983 (after Voelker 1991).*

conditions. Though most of the hulls were coated with Inerta, a few hulls were bare steel, and one hull was fitted with a stainless-steel band at the waterline. Performance measures included in their study are level-ice hull resistance, propulsive performance, hull lubrication, ridge resistance, turning performance and open water resistance. According to Keinonen et al. (1991), these results were compiled to understand the influence of key parameters on the performance of icebreakers. The key parameters chosen for this comparison were simple and obvious to all observers. For detailed information, readers are referred to their paper and to the reports prepared for that study. A summary of their performance predictors is given below.

Resistance in level ice

For chined ships, an expression for ice resistance at a speed of 1 m/s is given as

$$R_1 = 0.08+0.0177\, C_S\, C_H\, B^{0.7}\, L^{0.2}\, T^{0.1}\, H^{1.25}$$
$$\{1 - 0.0083\,(t + 30)\}\,\{0.63 + 0.00074\,\sigma_f\}$$
$$\{1 + 0.0018\,(90 - \psi)^{1.4}\}\,\{1 + 0.004\,(\varphi - 5)^{1.5}\}$$

where R_1 = resistance in level ice at 1 m/s (MN)
C_S = water salinity coefficient (saline = 1, brackish = 0.85 and fresh = 0.75)
C_H = hull condition factor (Inerta = 1, new bare steel = 1.33 and old bare steel = 2)
B = ship beam (m)
L = waterline length of ship (m)
T = draft of ship (m)
H = ice thickness, taken to be ice thickness plus half the snow depth (m)
t = ice surface or air temperature (°C)
σ_f = flexural strength of ice (kPa)
ψ = average flare angle in bow region (°)
φ = average buttock angle in bow region (°).

For rounded-shoulder ships, an expression (using the same symbols) for the ice resistance at a speed of 1 m/s is given as

$$R_1 = 0.015\, C_S\, C_H\, B^{0.7}\, L^{0.2}\, T^{0.1}\, H^{1.5} \{1 - 0.0083\,(t + 30)\}\, \{0.63 + 0.00074\, \sigma_f\} \{1 + 0.0018\,(90 - \psi)^{1.6}\}\, \{1 + 0.003\,\ (\varphi - 5)^{1.5}\}.$$

Energy to penetrate an unconsolidated ridge

Based on the full-scale data, an expression for the energy to penetrate an unconsolidated ridge is given as

$$E_R = 0.25\, A_C\, A_R\, C_S\, C_H\, \{1 - 0.0083\,(t + 30)\} \{1 + 0.012\,(90 - \psi)\}$$

where E_R = energy for ridge penetration (MJ)
A_C = largest cross-sectional area of vessel (m^2)
A_R = ridge depth × ridge profile length (rubble only) (m^2)
C_S = water salinity coefficient (saline = 1, brackish = 0.85 and fresh = 0.75)
C_H = hull condition factor (Inerta = 1, new bare steel = 1.33 and old bare steel = 2)
t = ice surface or air temperature (°C)
ψ = average flare angle in bow region (°).

Turning circle diameter

For vertical-sided chined vessels, and in level ice of thickness equal to 60% of the icebreaking capability at 1 m/s

$$D/L_{WL} = 38 \times 0.56^x$$

where D = turning diameter (m)
L_{WL} = length of waterline of ship (m)
x = reamer width relative to midbody length (%).

For rounded vessels with fully effective rudders, and in level ice of thickness equal to 60% of the icebreaking capability at 1m/s

$$D/L_{WL} = 0.022\,(PMB)^{1.75} + 3$$

where *PMB* is the percentage of waterline length representing a parallel midbody (%).

For rounded vessels with partially effective rudders, and in level ice of thickness equal to 60% of the icebreaking capability at 1 m/s

$$D/L_{WL} = 0.14\,(PMB)^{1.5} + 3.$$

Open water resistance

For chined vessels, open water resistance is expressed in terms of Froude number

$$R/Disp = 1.1\, F_n^{\,1.64}$$

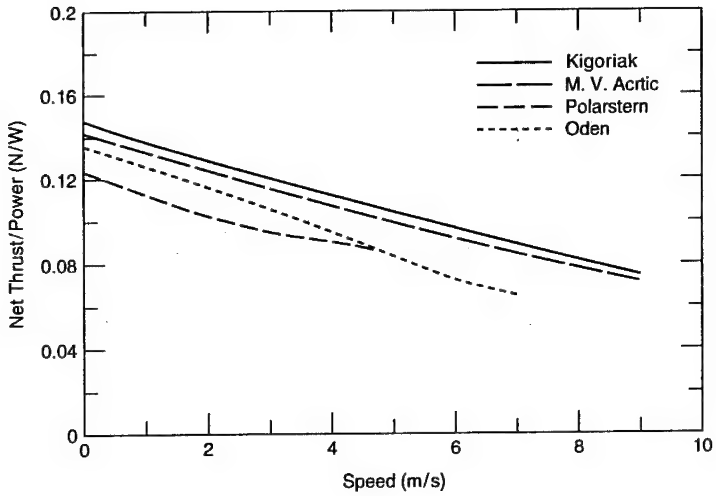
where R = open water resistance (kN)
$Disp$ = ship displacement (tons)
F_n = Froude number $\left(v/\sqrt{gL}\right)$
v = ship velocity
L = ship length between perpendiculars.

For vessels of rounded shapes, open water resistance is expressed in terms of Froude number

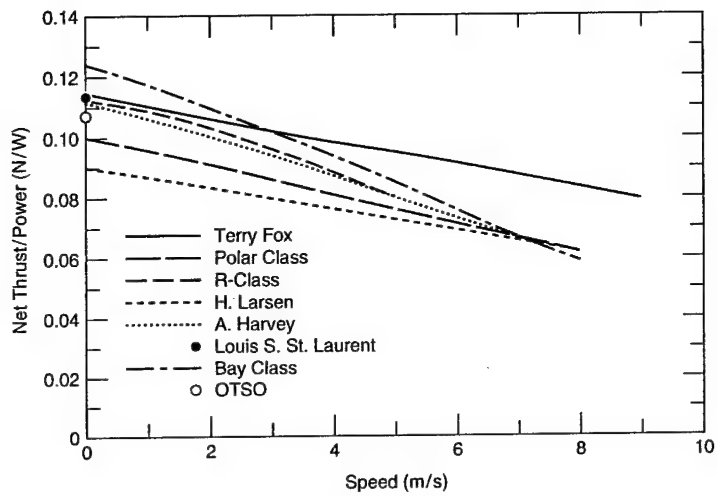
$$R/Disp = 0.4\, F_n^{\,1.68}.$$

Propulsive performance

Propulsive performance is defined as the ratio of net thrust to the shaft power (or specific net thrust). Keinonen et al. (1991) compared the propulsive performance of different icebreakers at full power. The data are shown in Figure 24a for different speeds for ships having ducted propellers, whereas similar data for ships with open propellers are shown in Figure 24b. A comparison of the data for the single-screw, ducted, controllable-pitch system of *Kigoriak* and *Arctic* with that of twin-screw, open, controllable-pitch system of *Terry Fox* shows that the net propulsive performance of the ducted systems has an advantage of 27% over the open system at low speeds. However, this advantage decreases at higher speed until both systems have the same specific net thrusts.



a. Propellers in nozzles.



b. Open propellers.

Figure 24. Specific net thrust vs. speed at maximum shaft power, indicating propulsive performance (after Keinonen et al. 1991).

FUTURE ICEBREAKERS

At present, some of the largest icebreakers, such as the Russian *Yamal*, are capable of operating in multi-year ice without any concern for possible damage, often at speeds in the range of 15–20 knots (7.7–10.3 m/s) (Brigham 1994). The icebreakers of this class are strongly built, with a robust propulsion system. Because of nuclear power, their unlimited endurance sets this class of ships apart from the rest of the icebreakers in the world. Detailed information about the icebreaker *Yamal* by R.K. Headlands of Scott Polar Institute is given in Appendix A, which states that the maximum ice thickness *Yamal* can penetrate while navigating is estimated to be 5 m, and that *Yamal* has broken through individual ridges estimated to be 9 m thick.

The contract to build an icebreaker, named *Healy*, for the U.S. Coast Guard has been executed, with a delivery scheduled for mid-1998.* Its displacement will be 16,303 tons, and its length, beam and maximum draft will, respectively, be 128 m, 25 m and 9.75 m. The propulsion systems will consist of 22.4 MW (30,000 hp), medium-speed diesel engines with ac–ac electrical transmission to drive two fixed-pitch propellers. Model tests indicate that it will be able to break 1.6-m-thick, level ice continuously. It will have a dynamic positioning system to support oceanographic research.

The design and model testing of a new U.S. Arctic Research Vessel has been completed (Kristensen et al. 1994), but it is not known at this time when this research vessel will be built. This vessel will support science missions in the Arctic well into

* Personal communication, A.D. Summy, Captain, U.S. Coast Guard, 1994.

the next century. The ship will have an overall length of 103.6 m, waterline length of 93.9 m, maximum beam of 27.1 m, depth of 12.2 m, draft of 9.1 m and a displacement of 11,684 tons. The vessel will have a flat bow with a ridge in the middle to break ice in bending and to clear it on the side, and a double hull to comply with the CASPPR guidelines. The propulsion system will include diesel engines of 15 MW (20,000 hp) and two-ducted 4.1-m-diameter controllable-pitch propellers.

As mentioned earlier, it is well within known and proven technology and experience to design, build and operate an icebreaker year-round independently in the Arctic. Keinonen (1994) has set down the performance criteria of a proposed icebreaker for the Northwest Passage, as given in Table 4. The design parameters of the icebreaker are given in Table 5, in which the values of those parameters for *Yamal* are also given for comparison. It can be seen that the icebreaker proposed for the Northwest Passage is slightly bigger in size and displacement than *Yamal*, but the designed installed power (from diesel engines with a mechanical transmission to two controllable-pitch propellers in nozzles) is less than that of *Yamal*, which is equipped with three propellers driven by nuclear power through an electrical transmission. Auxiliary systems for the Northwest Passage icebreaker include water wash and heeling tanks, as well as a stainless steel belt with Inerta coating elsewhere.

Figure 25 is a sketch of an "iceraker," as proposed by Johansson et al. (1994). The proposed iceraker has a vertical-sided, 50-m-wide hull that also has a submerged cantilever in front of and on each side of the vertical, wedge-shaped bow. At the edge of this cantilever, air is introduced into the water at a depth of about 15 m. Seven spurs are located on top of the cantilever at a transverse spacing of about 20 m. The spurs create a 120-m-wide channel of broken ice by deflecting a floating

Table 4. Performance criteria for a Northwest Passage icebreaker (after Keinonen 1994).

Performance	*Criteria/measure*	*Requirements*
Level ice	2 knots at continuous speed	3 m
Multi-year ice	Thickest broken ice on first ram	8 m
Backing	Thickest level ice ice broken in a continuous motion	2 m
Turning	Thickest ice below which turning circle is smaller than $10 \times L_{Wl}$	2 m
Extraction	Wind speed in which able to extract (also needs to be able to extract after any ram)	15.4 m/s (30 knots)

Table 5. Comparison of design parameters of proposed Northwest Passage icebreaker (Keinonen 1994) with those of the Russian icebreaker *Yamal*.

Parameter	*Unit*	*Proposed values for a Northwest Passage icebreaker*	*Values for the Russian icebreaker* Yamal
Displacement	ton	30,000	23,460
Water line length	m	140	136
Length of parallel mid body	m	70	no data
Beam at water line	m	30	28
Draft	m	14	11
Hull design concept	type	four-section bow	conventional, straight wedge shaped, double
Stem/buttock angle	degrees	17	17
Flare/frame opening angle	degrees	60	—
Shaft power	MW	40	56
Propellers	number/type	2CP in nozzles	3FP
Drive system	engine/transmission	diesel/mechanical	nuclear/steam turbine/ electrical
Reamers	type—width m	two way—2 m	none
Appendages	names	stern pods, shilling rudders, bottom wedge	ice horn
Auxiliary systems	types	water wash, heeling	air bubbler
Hull coating	types	Stainless and Inerta coating with cathodic protection	polymer coating

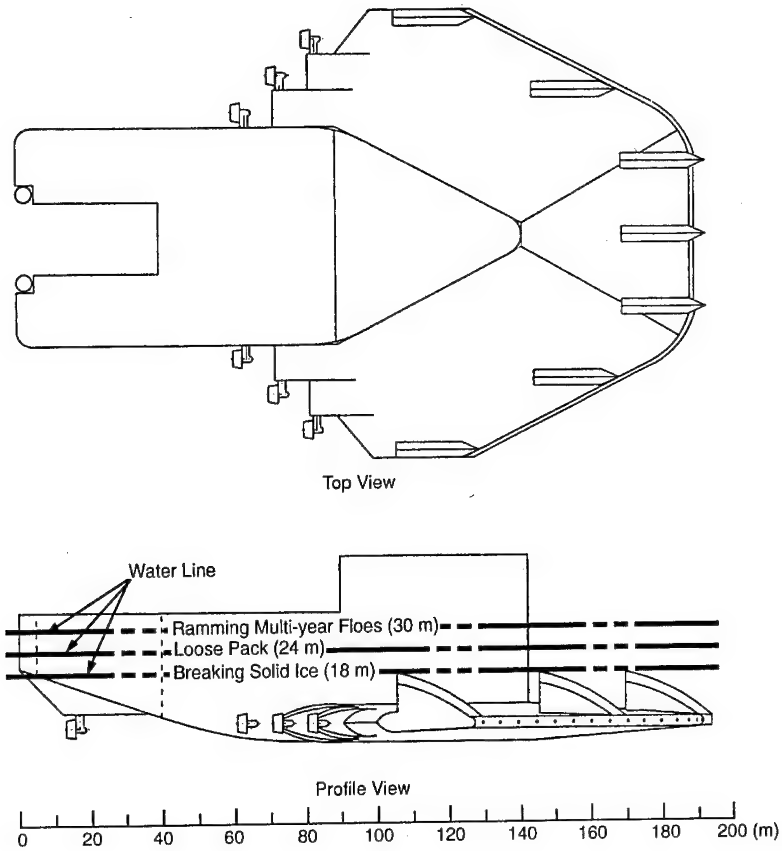


Figure 25. New "iceraking" concept, as proposed by Johansson et al. (1994).

ice sheet upward sufficiently to fracture it. The air released from the edge of the cantilever produces a current to take the broken ice pieces past the 60-m-wide main body of the iceraker. While moving through broken ice, the iceraker is submerged to a deeper level so that the spurs do not contact the ice. To break a thick (8-m) multiyear ice floe, the iceraker is submerged even deeper and allowed to strike the floe to split it in a single impact.

The proposed "iceraker" represents an innovation that may not become a reality for a long time. Enormous economic driving forces must be present to encourage building this type of vessel that is such a great departure from existing icebreaking ships.

SUMMARY

The current status of icebreaking technology has been presented, along with a brief history. The improvements in bow designs to break level ice efficiently were suggested more than a hundred years ago. However, those designs could not be implemented in sea-going ships because of ice-pushing problems. With the help of new developments to reduce friction between the ice and the hull of a ship, it has now become possible to build icebreakers with improved bow shapes to cope with any type of ice. The developments in marine propulsion systems were also incorporated into the icebreaking technology to obtain higher efficiency, reliability, flexibility and maneuverability. Development of auxiliary systems, such as heeling tanks, air-bubbler systems, water-deluge systems, low-friction coatings, etc., allows an icebreaker to perform effectively in ice conditions more severe than those for which they were designed.

A description of the Russian nuclear-powered icebreaker *Yamal* is given in Appendix A. An inventory of ships that are capable of navigating in at least 0.3-m-thick ice is presented in Appendix B.

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APPENDIX A: INFORMATION ABOUT THE NUCLEAR ICEBREAKER *YAMAL*

(Reproduced from an unpublished description given by R.K. Headland of Scott Polar Institute, Cambridge University, UK)

The ship is one of three *Rossiya* class icebreakers leased to the Murmansk Shipping Company by the Russian Government (her sisters are *Rossiya* [launched in 1985] and *Sovetskiy Soyuz* [1990]).

The name is derived from a Nenets word meaning "End of the Earth," also applied to the Yamal Peninsula.

Her keel was laid on 25-V-1986 in St. Petersburg and she was launched on 28-X-1992

Registered number M 43048 and International Call Sign UPIL.

Length overall 150 m, at waterline 136 m. Breadth overall 30 m, at waterline 28 m. Draft 11.08 m.

Height, keel to mast head: 55 m on 12 decks (4 below water).

Ice knife, a 2-m-thick steel casting, is situated about 22 m aft of the prow

Displacement 23,455 tonnes; capacity 20,646 gross registered tons.

The cast steel prow is 50 cm thick at its strongest point.

The hull is double with water ballast between them. The outer hull is 48 mm thick armor steel where ice is met and 25 mm elsewhere.

Eight bulkheads allow the ship to be divided into nine watertight compartments.

Ice breaking is assisted by an air bubbling system (delivering 24 m^3/s from jets 9 m below the surface), polymer coatings, specialized hull design and capability of rapid movement of ballast water. Ice may be broken while moving ahead or astern.

An M1-2 or KA-32 helicopter is carried for observing ice conditions ahead of the ship.

The ship is equipped to undertake short tow operations when assisting other vessels through ice.

Searchlights and other high intensity illuminations are available for work during winter darkness.

Complement 131: 49 officers and 82 other ranks.

Power is supplied by two pressurized water nuclear reactors using enriched Uranium fuel rods.

Each reactor weighs 160 tonnes, both are contained in a closed compartment under reduced pressure.

Fuel consumption is approximately 200 g per day of heavy isotopes when breaking thick ice. 500 kg of Uranium isotopes are contained in each reactor when fully fueled. This allows about 4 years between changes of the reactor cores.

Shielding of the reactor is by steel, high density concrete and water. The chain reaction can be stopped in 0.6 seconds by full insertion of the safety rods.

Used cores are extracted and new ones installed in Murmansk, spent fuel is reprocessed, and waste is disposed of at a nuclear waste plant.

Ambient radiation is monitored by 86 sensors distributed throughout the vessel. In accommodation areas this is 10 to 12 μRöntgen/hr, within the reactor compartment, at 50% power, 800 μRöntgen/hr.

The primary cooling fluid is water, which passes directly to four boilers for each reactors; steam is produced at 30 kg/cm^2 (310°C).

Main propulsion system: each set of boilers drives two steam turbines that turn three dynamos (thus six dynamos may operate). 1 kV dc is delivered to three double-wound motors connected directly to the propellers.

Electricity for other purposes is provided by five steam turbines turning dynamos that develop a total of 10 MW.

There are three propellers; starboard and midships ones turn clockwise, port turns counter-clockwise. Shafts are 20 m long. Screw velocity is between 120 and 180 rpm.

Propellers are fixed, 5.7 m diameter and weigh 50 tonnes; each has four 7-tonne blades fixed by nine bolts (16 tonne torque applied); inspection wells allow them to be examined in operation.

Four spare blades are carried; diving and other equipment is aboard so a blade may be replaced at sea; each operation takes from 1 to 4 days (three such changes have been necessary on *Rossiya* icebreakers since 1985).

A propulsive effort of 480 tonnes can be delivered with 18–43 MW (25,000 shaft horsepower) from each screw (total 55.3 MW [75,000 shaft horsepower]).

Power can be controlled at a rate of 1% a second.

Maximum speed is 22 knots (40 km/hr); full speed in open water is 19.5 knots (35 km/hr); breaking ice 2–3 m thick can be done at 3 knots (5.5 km/hr) continuously.

Maximum ice thickness that can be penetrated while navigating is estimated as 5 m; individual ridges estimated at 9 m thick have been broken through.

Helm controls one rudder, which turns 35° either way, operated by four hydraulic cylinders powered by one of two pumps. It is protected by an ice-horn for moving astern.

Steering may also be provided by directing air jets of the bubbling system (comparable to use of bow-thrusters).

Auxiliary power is available from three diesel generating sets: 1 MW (1×) and 250 kW (2×).

Anchors: two 7-tonne anchors with 300 m of chain each, and four ice anchors.

Four deck cranes are aboard; the largest pair can lift 16 tonnes each.

Sea water distillation: two vacuum stills can supply 5 m^3 of fresh water an hour each (240 m^3/day).

Differential ballast tanks are suitable fore and aft, and athwart the ship; the pumps are capable of moving 1 m^3 of water a second.

Ship has 1280 compartments (cabins, storage areas, machine rooms, etc.).

Sufficient provisions and supplies can be carried to operate for 7 months.

Safety equipment includes: 1 launch, 2 fully enclosed lifeboats, and 18 inflatable life rafts.

APPENDIX B: AN INVENTORY OF EXISTING SHIPS THAT ARE CAPABLE OF NAVIGATING IN AT LEAST 0.3-m-THICK ICE COVER

(Inventory compiled by Leonid Tunik)

TABLE OF CONTENTS

INTRODUCTION

This database has been developed in order to provide a user with an inventory of operating ships capable of navigation and marine trade over the Northern Sea Route (NSR) in the Russian Arctic, as well as in other ice-infested Arctic and Antarctic waters. Since the NSR, also known as the North-East Passage, is situated entirely within the Russian national waters, all navigation along the route is regulated by Russian authorities. Several regulatory and administrative agencies are involved, both directly and indirectly.

REGULATORY AGENCIES

NORTHERN SEA ROUTE ADMINISTRATION

The Moscow-based Northern Sea Route Administration, Dept. of Marine Transport, Ministry of Transportation, is the agency authorized to issue and publish official state regulations for navigation on the NSR. Since the Route has only recently been opened to foreign ships and mariners, the Administration issued its first "Regulations for Navigation on the Seaways of the Northern Sea Route" in 1991. The NSR Administration is also responsible for issuing and withdrawing permits for all non-Russian-flag and non-Russian-Register-classed ships passing throughout the route, as well as for issuing and withdrawing permits for the captains and mates to pilot the non-Russian ships in ice-infested waters on the route. The Administration is a regulatory body that does not control day-to-day operations on the NSR.

STAFFS OF MARINE OPERATIONS (SMO)

Traffic in ice-covered waters of the NSR is usually maintained year-round over the Western part of the route–the Barents and Kara Seas and Enisey Bay. The Eastern part is maintained from spring to early winter. The traffic usually involves more than a hundred ships over the entire route during the summer season, and falls to several dozen ships during the winter season. Day-to-day control of this traffic in ice conditions is carried out jointly by two executive offices of Staff of Marine Operations (SMO): the Dickson-based Western SMO and Pevek-based Eastern SMO, both controlling their respective parts of the route. The SMO offices are mainly comprised of the major shipping companies and include representatives from the NSR Administration, local administrations, supporting organizations (Hydro-Meteorological Service, Polar Aircraft and Helicopter Companies, Fuel Suppliers, etc.), and Navy liaisons. The major responsibilities of the Staffs include organization of caravans escorted by icebreakers, coordination of icebreaker operations over the route to maintain navigable channels, distribution of real-time information on ice-hydro-meteorological conditions over the route, management of emergency situations, coordination of piloting service, etc.

MURMANSK SHIPPING CO., FAR-EASTERN SHIPPING CO.

Murmansk Shipping Company (MSC), based in Murmansk, and Far-Eastern Shipping Company (FESC), based in Vladivostok, are owners of the world's largest Polar icebreaker fleet. Together they own more icebreaking gross tonnage and total shafthorsepower than the rest of the world combined. All nuclear-powered icebreakers and the only nuclear-powered icebreaking cargo vessel are owned by MSC.

RUSSIAN REGISTER OF SHIPPING (RR)

Russian Register of Shipping (Morskoi Reghistr Rossiiskoi Federatsii), based in St. Petersburg, is not involved in issuing the permits for navigation on the NSR. However, this agency may be requested

to evaluate the adequacy of ice strengthening of a particular ship in the framework of RR ice classification.

THE NAVY

The Russian Navy is not directly involved in the process of issuing permits and controlling navigation. However, any permit to a non-Russian ship has to be approved by a regional Naval office.

REGULATIONS.

NSR Administration published an official document stating the regulations governing the navigation on the NSR, entitled: Regulations for Navigation on the Seaways of the Northern Sea Route, (Moscow, 1991, hereafter referred to as NSR Regulations). The document outlines the general requirements and procedures for obtaining permits for entry to the NSR waters by non-Russian ships. The document refers to two other documents entitled: Requirements for the Design, Equipment and Supply of Vessels Navigating the NSR (Moscow, 1991, hereafter referred to as NSR Requirements), and Guide for Navigation Through the NSR (hereafter referred to as NSR Guide). The NSR Guide has not yet been published as of June 30, 1994. The NSR Requirements explicitly state that navigation on the NSR is allowed only for ships strengthened to ice categories L1, UL and ULA of Russian Register's Rules for Classification and Construction of Sea-Going Ships, (1990, hereafter referred to as RR Rules), or their equivalents in the Rules of other classification societies (see Table). This requirement is in accord with the definition of ice categories given by the RR Rules, which defines ice category L1 as the lowest class suitable for independent Arctic navigation in light summer ice conditions only. Technically, the NSR Requirements do not close the door for ships of lower ice categories (L2 and L3 of Russian Register Rules), but highly discourage them from applying for permits, hindering the permission for those ships by many "ifs", "special considerations" and higher fees.

Table 1. Inter-Register ice class equivalence, as defined in NSR Regulations.

	UL & equivalent	L1 & equivalent
GL	E4	E3
LR	I*, IA Super	I, IA
BV	I Super, IA Super	I, IA
DNV	1A*, 1A*F	1A
ABS	A1, IAA	A0, IA
RI	RGI*, IAS	RGI, IA
NKK	AA, IA Super	A, IA
FSIR	IA Super	IA

SHIPS INCLUDED

The restrictions made by the "Russian Requirements", and the design of this directory for marine traders dictate that the ships included be limited by the level of ice strengthening (ice class) and the type of ship. Above the ice class equivalence defined above in Table 1 a relative ranking table of all ice classes fit for navigation on the NSR (see Table 2) has been compiled for this database. All ships of ranks 1 and 2, virtually all ships of rank 3, and a great majority of rank 4 were included, based on their ice capabilities.

Table 2. Ice class ranking and equivalence by register.

	Rank 1	Rank 2	Rank 3	Rank 4
RR	LL1, LL2, LL3	LL4, ULA	UL & equivalent	L1 & equivalent
GL	Arc4, Arc3, Arc2	Arc1		
LR	AC3, AC2, AC1.5	AC1		
DNV	Polar-30, Polar-20	Polar-10, Ice-15, Ice-10		
ABS	A5, A4, A3	A2		
CASPPR	10, 8, 7, 6, 4	1, 2	A	B

The types of ships included are: commercial cargo vessels designed for marine trade, purpose icebreakers of non-military ownership, and scientific icebreaking ships. Specific type categories are listed in the Index Section of the report. For the sake of completeness, the U.S. and Canadian Coast Guard icebreakers are also included, as well as icebreakers owned by other governments. With regard to the ice class, the inventory includes: (a) icebreakers of all ice classes with an exception of, perhaps, some small ones intended for operations within ports, shallow rivers and small lakes; (b) virtually all ships strengthened to ice class of UL and above, or equivalent, and (c) a great majority of vessels of ice class L1 and its equivalent. Some ships included in this database have been recently decommissioned.

SCOPE OF DATA

The data for each vessel include vessel name, flag, ownership, home port, type of ship, principal dimensions, displacement, tonnage, cargo capacity, type and principal characteristics of propulsion machinery and propellers, ice propulsion capabilities, crew, special features enhancing cargo handling and maneuvering during mooring, fuel consumption rates where available, and itemized operating costs where available. Beyond these, other data which are deemed useful may also be added, namely: registry, general class notation and the assigned ice class (category), year and country of construction, former names, special features enhancing ice capabilities (unconventional shapes, water jet washing system, low friction-abrasion coating, etc.) for icebreakers and icebreaking Arctic cargo ships only.

NOTES TO THE PRINTED EDITION

MAIN LISTING

The Printed Edition of this database is designed for a reader looking for available ships of a certain type and ice class. Thus, ships of the same series are listed together in the same record, and the records are ordered alphabetically by the name of the series. Non-serial ships are treated as a series of one ship. The first part of a record contains information common to all the ships in the series: the name of the series, ice class, type of ship, principal specifications, and any modifications in the design of the series since the commission of the first ship. Then the particular ships belonging to that series are listed in alphabetical order with their respective information such as the name of the ship, flag, owner's name, register, year of commission, costs of operation and lease (where available), and any modernizations made to the ship after its commission.

OWNERS LISTING

Owners of the ships are listed alphabetically. The listings contain the owner's company name, address, telephone, fax, and telex. See the Index section for a list of ships by a particular company.

INDICES

There are indices for those who are looking for a particular ship by its name or by ice capability.

NOTES TO THE ELECTRONIC EDITION

The database is supplied in two electronic forms: 1) a set of normalized tables for incorporation into a larger database project and 2) a non-normalized table designed for immediate browsing and statistical analysis. The latter is an ASCII text file delimited with quotes and separated with commas, ready for importing into a spreadsheet program. The former is described below.

DATABASE FILE STRUCTURE

The data in the table files included have been normalized as much as was feasible for a compromise between ease of export and for integration into a larger project. The Main Tables described below contain the information about the ships, series, and owners, while the Look-up Tables contain the explanations of reference codes used in the Main Tables, e.g. Register names, ship type codes etc. Some fields in different tables have been given identical names for ease in incorporation into a relational database. Following are brief descriptions of each table, and a layout of their relationships in a schematic form.

LIST OF TABLES INCLUDED

MAIN TABLES:	LOOK-UP TABLES:
SERSPECS	BOW
SISTERS	REGISTER
COMPANY	PROPMACH
SHTYPE	COUNTRY
ICERANK	TYPE

MAIN TABLE DESCRIPTIONS

Following is the breakdown of the structure of each table, including the field name, type, length, number of decimal places if numeric, and index direction, as well as a brief description of the contents and units used in data entry. Memo types are generally fields that require more than 50 characters, such as descriptions of special equipment, modifications, cost information etc.

SERSPECS

SERSPECS contains information that is essentially the same for ships of the same series. This includes ice rank and class, principal dimensions and characteristics, and auxiliary features and systems common for the entire series, as well as information about modifications introduced after some ships had already been built. Each record is uniquely identified by field SERNUM (4 digits, character format), the reference number for the entire series of ships. The records in this table do not actually represent particular ships, only a set of specifications that corresponds to a set of ships. Thus, there is no field for ship name in this table.

Field Name	Type	Width/ Dec	Index	Description
SERNUM	Char	4	Asc	Series ID number
MODIFIC	Memo	10		Modification description
SERIESNAME	Char	25	Asc	Name of the series
SERIESSIZE	Num	3/0		Size of the series
ICECLASS	Char	6		Ice class assigned
LOA	Num	6/2		Overall length, m.
LBP	Num	6/2		Length bet. perpendiculars or design waterline, m.
BMOLD	Num	6/2		Molded breadth, m.
BMAX	Num	6/2		Overall breadth, m.
DEPTH	Num	6/2		Depth, m.
DWL	Num	6/2		Molded draft at design waterline, m.
DARC	Num	6/2		Arctic draft, m.
DMAX	Num	6/2		Max. draft, m.
DISPL	Num	7/0		Displacement at design draft, t.
DISPLARC	Num	7/0		Displacement Arctic draft, t.
DISPLMAX	Num	7/0		Displacement at max. draft, t.
DWT	Num	7/0		Deadweight at design draft, t.
DWTARC	Num	7/0		Deadweight at Arctic draft, t.
DWTMAX	Num	7/0		Deadweight at max. draft, t.
GROSS	Num	7/0		Gross tonnage, t.
CARGO	Char	50		Total cargo capacity, units incl.
BOWSHAPE	Char	4		ID code identifying the bow shape
STEMANG	Num	3/0		Stem inclin. angle to the waterline at DWL, deg.
PROPPWR	Num	6/0		Power at the propellers, kW
MACHPWR	Num	6/0		Power of the ship's machinery at flanges
THRUST	Num	6/0		Thrust of propellers in bollard conditions, tf
PROPMACH	Char	4		ID code identifying machinery type
PROPNUM	Num	1/0		Number of propellers
PWRDIST	Char	10		Power distribution among propellers
PROPTYPE	Char	16		Type of propellers
PROPDIAM	Num	4/2		Diameter of the propellers, m.
PROPBLDS	Char	20		Number of blades in the propeller
NOZZLES	Char	2		Availability of propeller nozzles
NOMSPD	Num	5/2		Nominal speed, kn.
RANGE	Char	20		Nominal range, units incl.
FUELCAP	Char	10		Maximum fuel capacity, units incl.
ICECAP	Char	50		Ice breaking capacity, m.@kn.
AUXSYS	Memo	10		Auxiliary icebreaking systems
CREW	Num	3/0		Number of crew members
THRUSTERS	Char	2		Availability of bow thrusters
FUELRATE	Char	12		Fuel consumption rate, units inc.
HELI	Memo	10		Availability of helicopter
SPECFEATR	Memo	10		Special features other than auxiliary icebreaking systems
UNLOADEQ	Memo	10		Equipment for unloading on unequipped shore
COMMENTS	Memo	10		General comments
REFERENCES	Memo	10		Literature for further information

SISTERS

SISTERS contains information that is unique to each particular ship. This includes the names of the ship, shipyard, register and owner, flag, costs, and special features and modifications peculiar to that ship. The records in this table are uniquely identified by field SHIPNUM (4 digits, Char format)

(whose values bear no connection to SERNUM from SERSPECS, though they are of the same format for the sake of simplicity). This table does not duplicate any information contained in SERSPECS.

Field Name	Type	Width	Index	Description
SHIPNUM	Char	10		ID number of the ship
NAME	Char	50	Asc	Name of the ship
SERNUM	Char	4		ID number of the series the ship belongs to
FIRST	Y/N	1		First in a series or not
EXNAMES	Char	50		Former names
ICEREG	Char	4		Ice register which assigned ice class to the ship
SHIPYARDID	Char	8		ID number of the shipyard
REGISTER	Char	4		Register, if other than Ice Register
FLAG	Char	4		Flag of the ship
REGNUMBER	Char	10		Register number from Lloyd's Register of Shipping
OWNERID	Char	8		ID of the owner company
HOMEPORT	Char	50		Home port
YRBUILT	Num	4/0		Year built
MODERNIZ	Memo	10		Modernizations description and year
OPCOSTS	Memo	10		Operational costs
CHRTRATE	Memo	10		Charter rate
SPECFEATR	Memo	10		Special features particular to the ship
NOTES	Memo	10		General notes

COMPANY

COMPANY contains information about the owners and shipyards. Each record is given a unique 6-Char ID composed of a combination of letters taken from the company name. The formula used for making the ID is as follows:

- Exclude following words: "Co", "Ltd", "Inc.", "&", "and", as well as prepositions and articles;
- Take the first 4 Chars of first word, or whole word if less than 4 Chars long;
- Add the first letter of the second word, or fill to 6 chars if only two words in the name;
- Add the first letter of the third word of the name.

Field Name	Type	Width	Index	
OWNERID	Char	8		ID number identifying the company
COMPANY	Char	50	Asc	Name of the company
CONTACT	Char	30		Contact name
ADDRESS1	Char	50		First line of address
ADDRESS2	Char	50		Second line of address
CITY	Char	40		City
STATE_PROV	Char	30		State or province
ZIP_POSTAL	Char	10		Zip code or postal code
COUNTRY	Char	25		Country
TEL	Char	20		Telephone
FAX	Char	20		Fax
EMAIL	Char	25		Electronic mail
TELEX	Char	16		Telex

SHTYPE

SHTYPE assigns ship types to the ships in the SISTERS table. There will be more than one type assigned to some ships, so this table is on the "many" side of a 1-to-many relationship with the SISTERS table. Each record of the table contains a SHIPNUM and one corresponding SHTYPE code. The description of each SHTYPE code can be looked up in the TYPES table.

Field Name	Type	Width	Index	Description
SERNUM	Char	4	Asc	Series ID number
SHTYPE	Char	20		Type of ship corresponding to the series

ICERANK

ICERANK assigns an internal relative ice rank to each ice class contained in field ICECLASS of SERSPECS. This lookup table uses the information given in Table 2. Ice class ranking and equivalence by register.

Field Name	Type	Width	Index	Description
REGID	Char	4	Asc	ID for the ice register
REGNAME	Char	50		Name of the register
ICECLASS	Char	10		Ice class
ICERANK	Char	1		Ice rank assigned

LOOK-UP TABLE DESCRIPTIONS

BOW

BOW is a look-up table of bow shape codes used in the BOWSHAPE field of the parent SERSPECS table.

Field Name	Type	Width	Index	Description
BOWSHAPE	Char	4	Asc	ID code for the shape of the bow
SHAPE	Char	70	Asc	Description of the shape of the bow

REGISTER

REGISTER is a look-up table of register codes used in field REGISTER of SISTERS

Field Name	Type	Width	Index	Description
REGACR	Char	4	Asc	ID code for the register name
REGISTER	Char	30		Register name

PROPMACH

PROPMACH is a look-up table of machinery types used in field PROPMACH of SERSPECS.

Field Name	Type	Width	Index	Description
PROPMACH	Char	4	Asc	ID code for the type of propulsion machinery
MACHINERY	Char	35	Asc	Type of propulsion machinery

COUNTRY

COUNTRY is a look-up table of country codes used in field FLAG of SISTERS

Field Name	Type	Width	Dec	Description
CO	Char	2	Asc	ID code for the country
COUNTRY	Char	35		Country name

TYPES

TYPES is a look-up table of ship type codes contained in field SHTYPE of the SHTYPE table

Field Name	Type	Width	Index	Description
SHIPTYPE	Char	4	Asc	ID code for ship type
TYPE	Char	50		Ship type

TABLE RELATIONSHIPS

From table/field		To table/field	Relationship
SISTERS table SERNUM field	▷	**SERSPECS** table SERNUM field	1 to 1
OWNERID field	▷	**OWNER** table OWNERID field	1 to 1
SHIPYARDID field	▷	**SHIPYRDS** table SHIPYARDID field	1 to 1
REGISTER field	▷	**REGISTER** table REGACR field	1 to 1
FLAG field	▷	**COUNTRY** table CO field	1 to 1

From table/field		To table/field	Relationship
SERSPECS table ICECLASS field	▷	**RANKING** table ICECLASS field	1 to 1
PROPMACH field	▷	**PROPMACH** table PROPMACH field	1 to 1
BOWSHAPE field	▷	**BOWSHAPE** table BOWSHAPE field	1 to 1
SERNUM field	▷	**SHTYPE** table SERNUM field	1 to 1

From table/field		To table/field	Relationship
SHTYPE table ICECLASS field	▷	**TYPES** table SHIPTYPE field	1 to Many

ACRONYMS USED

REGISTER NAMES

ABS	American Bureau of Shipping
BV	Bureau Veritas
CR	Canadian Arctic Shipping Pollution Prevention Regulations (CASPPR)
DNV	Det Norske Veritas
FR	Finnish-Swedish Ice Rules (FSIR)
GL	Germanisher Loyd
LR	Lloyd's Register of Shipping
NKK	Nippon Kaiji Kuoky
RI	Registro Italiane Navale
RR	Russian Register

BOW SHAPE

CONS	Conventional plain wedge with straight-line stem and bottom stopper
CONV	Conventional plain wedge with straight-line stem
CONC	Conventional wedge with curvilinear line stem and bottom stopper
SPOO	Spoon-shaped
THYS	Thyssen-Waas
SLED	Sledge shaped
SLOP	Sloped plane with wedge

COUNTRY

AL	Australia	JP	Japan
AR	Argentina	LB	Liberia
AS	Austria	LH	Lithuania
AZ	Azerbaidjan	LT	Latvia
BH	Bahamas	ML	Malta
BL	Bulgaria	NR	Norway
CN	Canada	PL	Poland
CY	Cyprus	PN	Panama
ES	Estonia	RC	Republic of China
FN	Finland	RF	Russian Federation
GB	Great Britain	RM	Romania
GC	Greece	SP	Spain
GN	The Grenadines	SW	Sweden
GO	Republic of Georgia	TR	Turkey
GR	Germany	UK	Ukraine

HG	Hungary	US	U.S.A.

SHIP TYPES

ASRV	Antarctic supply research vessel
BULK	Bulk carrier
CGIB	Coast Guard icebreaker
CHEM	Chemical transport
CONT	Container carrier
DRED	Dredge
DRIR	Drilling rig
DRIS	Drilling ship
FERR	Ferry
HLV	Heavy lift vessel
IB	Purpose Icebreaker
LASH	LASH & container carrier
MPC	Multi-purpose cargo
MPIB	Multi-purpose icebreaker
MSH	Mother ship for submersibles
OTHE	Other type
PASS	Passenger
PATR	Patrol boat
PIB	Polar icebreaker
REFR	Refrigerator
RIB	River icebreaker
RORO	Roll on - Roll off
RV	Research vessel
SALV	Salvage tug
SUBM	Submersible
SUPP	Supply ship
SWIB	Shallow-water icebreaker
TANK	Tanker
TIMB	Timber carrier
TUG	Tug

PROPULSION MACHINERY

DIEL	Diesel-electric
MSDG	Medium-speed Diesel-geared
NPTE	Nuclear-powered Turbo-electric
SSDG	Slow-speed Diesel-geared
TUEL	Turbo-electric

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SERIES NAME	SERIES SIZE	LBP	Bmold	DWL	POWER
Highland Sentinel		60.39	12.80	4.77	5176
IgarkaLes	9	93.28	14.00		2130
Ilyich	1	115.80	22.00	5.42	13240
Jaguar		80.40	15.63	5.90	
Kapitan Gavrilov	10	192.73	25.40		15660
Kapitan Lus		89.40			3360
Kapitan Panfilov	11	134.40			4930
Kiisla		105.20	17.60	6.60	3700
Komandor	4	82.20	13.60	4.70	56704
Kosmonavt Pavel Beliayev		113.00	16.69		3825
KotlasLes	15	93.00	14.00		2130
Krymsk	21	94.50			2130
Krystall	1	142.00	22.00		7600
LadogaLes	6	93.02	13.85	5.91	2133
Marinor		104.66	18.00	7.50	
Mariya Yermolova		90.00	16.21	4.65	38821
Mary Christina		84.90		5.30	1850
Mekhanik Yartsev	10	79.40	14.20	4.70	2074
Mikhail Kalinin		109.99	15.96		6106
Mirnyy	46	93.02	14.00	6.20	2133
Nikolay Novikov	25	139.86			7060
Nikopol	6	74.00			1470
Novaya Ladoga (Pr. 596)		113.01	16.69	5.99	3825
Novy Donbass	2	90.00	13.90		1840
Petrozavodsk	20	112.78	16.69		3825
Pioner	30	96.00	15.60		2390
Posiet	4	93.40	17.00		7502
Povenets	23	96.00	14.60		2390
Professor Goryunov		101.00		6.50	7156
Rheinstern	4	153.00		8.50	6600
Seapower		60.39	12.80	4.77	5176
Sergei Kirov	2	142.00	23.80		8700
Shuhle Geteborg		82.50		3.60	2370
SibirLes	12	94.50	14.33		2130
Sibirski					
Sosnovets	11	71.20			1100
Sovetskaya Yakutiya	8	117.00	15.00		1472
Sovetskii Voin	20	74.21	12.48	5.40	1839
Spartak	14	69.74	11.50		1100
Stakhanovets Kotov	2	121.00	20.20		4810
SukhonaLes		93.91	14.33	5.78	1471
Svetlomor-1		51.80	14.00	4.50	
Tebo Olimpia	1	132.80	21.20	7.30	5560
Temriuk		74.00	11.97	4.65	1471
Trans Dania		106.40	17.50	6.71	3000
Uglegorsk		90.22	17.30	5.62	3360
Viiralaid	5	70.80			1553
Vitalii Diakonov	11	116.96	15.80	4.50	2200
VolgoLes	4	115.00	16.70		3310
Weserstern	2	104.60	17.70	8.54	
World Discoverer		72.70	15.20	4.46	3529

SHIPS v. SERIES NAME

A reference for finding the series listing for a particular ship

SHIP NAME	LISTED UNDER SERIES
Abakan	Igor Ilyinski
Admiral Makarov	Yermak
Admiral Ushakov	Dmitry Donskoi
Afanasiy Bogatyryov	Sovetskaya Yakutiya
Akademik Fedorov	Akademik Fedorov
Akademik Ioffe	Akademik Sergei Vavilov
Akademik Nalivkin	Akademik Nalivkin
Akademik Pozdyunin	Vitalii Diakonov
Akademik Sergei Vavilov	Akademik Sergei Vavilov
AlatyrLes	VolgoLes
Aldan	SibirLes
Aleksandr Dovzhenko	Aleksandr Dovzhenko
Aleksandr Fadeyev	Alexandr Fadeev
Aleksandr Kaverznev	Aleksandr Kaverznev
Aleksandr Miroshnikov	Sovetskii Voin
Aleksandr Nevskiy	Dmitry Donskoi
Aleksandr Pankratov	Sovetskii Voin
Aleksandr Prokofyev	Alexandr Fadeev
Aleksandr Suvorov	Dmitry Donskoi
Aleksandr Tvardovskiy	Alexandr Fadeev
Aleksey Chirikov	Vitus Bering
Aleksey Kosygin	Alexey Kosygin
Alla Tarasova	Mariya Yermolova
Almaz	Almaz
Almirante Irizar	Almirante Irizar
AltayLes	BelomorskLes
Amderma	Norilsk (a.k.a. SA-15)
Anadyr	Norilsk (a.k.a. SA-15)
Anatoliy Kolesnichenko	Anatoliy Kolesnichenko
Anatoliy Lyapidevskiy	Mikhail Strekalovski
Anatoliy Sibiryakov	Pavlin Vinogradov
Andrey Ivanov	Sovetskii Voin
Angarsk	Partizansk
Anna Akhmatova	Anna Akhmatova
Anna Karenina	Anna Karenina
Anton Buyukly	Krymsk
Antonina Nezhdanova	Mariya Yermolova
Aranda	Aranda
Arctic	Arctic
Arctic Tuktu	Arctic Tuktu
Arcticshelf	Arcticshelf
Arkadiy Kamanin	Pioner
Arkhanghelsk	Norilsk (a.k.a. SA-15)
Arktika	Arktika
Arseniy Moskvin	Sovetskii Voin
Arsenyev	Partizansk
Atlas	Almaz
Atle	Atle
Aurora Austrelis	Aurora Austrelis
Ayan	SibirLes
Bakaritsa	Novaya Ladoga (Pr. 596)
Bakhchisaray	Balkhash
Balkhash	Balkhash
Baltic Press	Baltic Press
Baltic Print	Baltic Press
BAM	Samotlor
Bars	Jaguar
Baykal	Mikhail Kalinin
Baykonur	BelomorskLes
Belogorsk	Partizansk
BelomorskLes	BelomorskLes
Belomorye	Balkhash
Beloyarsk	Temriuk
Beryozovo	Samotlor
Blagoveshensk	Mirnyy
Boris Nikolaychuk	Krymsk
Borya Tsarikov	Pioner
Botsman Moshkov	Nikolay Novikov
Bratsk	Norilsk (a.k.a. SA-15)
Bukhtarma	Povenets
Canmar Explorer	Canmar Explorer
Canmar Explorer II	Canmar Explorer
Canmar Kigiriak	Canmar Kigiriak
Chazhma	Mirnyy
Chekhov	Uglegorsk
Cherepovets	Sosnovets
Dallnerechensk	Ventspils
Darasun	BelomorskLes
Daugava	Ventspils
De Kastri	Uglegorsk
Dikson	Mudyug
Discoverer 534	Discoverer 534
Discoverer Seven Seas	Discoverer 534
Discovery	Discovery
Dmitriy Ovtsyn	Dmitriy Ovtsyn
Dmitriy Pozharskiy	Dmitry Donskoi
Dmitriy Sterlegov	Dmitriy Ovtsyn
Dmitry Donskoi	Dmitry Donskoi
Drogobych	Drogobych (Ocean A/B)
Dunker	Dunker
DvinoLes	VolgoLes
Dzhurma	BelomorskLes
Eduard Toll	Dmitriy Ovtsyn
Egvekinot	SibirLes

SHIP NAME	LISTED UNDER SERIES	SHIP NAME	LISTED UNDER SERIES
Elbestern	Emsstern	**IzhmaLes**	IgarkaLes
Elektrostal'	BelomorskLes	**IzhoraLes**	IgarkaLes
Emsstern	Emsstern	**James Clark Ross**	James Clark Ross
EPRON	Almaz	**Jose Diaz**	Mirnyy
Estonia	Mikhail Kalinin	**Kaliningrad**	Mirnyy
Fastov	Fastov	**Kalvik**	Terry Fox
Fennica	Fennica	**KamaLes**	IgarkaLes
Finnfellow	Finnfellow	**Kamchadal**	Mirnyy
Finnfighter	Finnfighter	**Kamchatskiy Komsomolets**	Mirnyy
Finnmaid	Finnfellow	**Kamensk-Uralskiy**	Samotlor
Finnmerchant	Finnmerchant	**Kandalaksha**	Norilsk (a.k.a. SA-15)
Franklin	Piere Radisson	**Kansk**	BelomorskLes
Frej	Atle	**Kapitan A. Radjabov**	Kapitan M. Izmailov
Frontier Spirit	Frontier Spirit	**Kapitan Babichev**	Kapitan Yevdokimov
Fyodor Litke	Vasilii Pronchischev	**Kapitan Bakanov**	Nikolay Novikov
Fyodor Matisen	Dmitriy Ovtsyn	**Kapitan Beklemishev**	Almaz
Fyodor Okhlopkov	Sovetskaya Yakutiya	**Kapitan Belousov**	Kapitan Belousov
Fyodor Popov	Sovetskaya Yakutiya	**Kapitan Bochek**	Mikhail Strekalovski
Fyodor Varaskin	Nikolay Novikov	**Kapitan Borodkin**	Kapitan Yevdokimov
Gastello	Uglegorsk	**Kapitan Bukaev**	Kapitan Chechkin
Gerakl	Gerakl	**Kapitan Burmakin**	Nikolay Novikov
Glomar Beaufort Sea I	Glomar Beaufort Sea I	**Kapitan Chadaev**	Kapitan Chechkin
Gorno-Altaysk	Posiet	**Kapitan Chechkin**	Kapitan Chechkin
Gornopravdinsk	Samotlor	**Kapitan Chmutov**	Kapitan Goncharov
Grosselier	Piere Radisson	**Kapitan Chudinov**	Kapitan Yevdokimov
Guryev	Partizansk	**Kapitan Chukhchin**	Mikhail Strekalovski
Guse-Khrustalnyi	Mirnyy	**Kapitan Danilkin**	Anatoliy Kolesnichenko
Henry Larsen	Henry Larsen	**Kapitan Demidov**	Kapitan Yevdokimov
Highland Sentinel	Highland Sentinel	**Kapitan Djachuk**	Drogobych (Ocean A/B)
Icha	Temriuk	**Kapitan Dotsenko**	Drogobych (Ocean A/B)
Igarka	Norilsk (a.k.a. SA-15)	**Kapitan Dranitsyn**	Kapitan Sorokin
IgarkaLes	IgarkaLes	**Kapitan Dublitskiy**	Nikolay Novikov
Igor Grabar	Igor Grabar	**Kapitan Gastello**	Mirnyy
Igor Ilyinski	Igor Ilyinski	**Kapitan Gavrilov**	Kapitan Gavrilov
Igrim	Samotlor	**Kapitan Glazachev**	Nikolay Novikov
Ikaluk	Ikaluk	**Kapitan Glotov**	Pavlin Vinogradov
Iljinsk	Mirnyy	**Kapitan Gnezdilov**	Kapitan Sakharov
Ilyich	Ilyich	**Kapitan Goncharov**	Kapitan Goncharov
Indiga	LadogaLes	**Kapitan Gotskii**	Kapitan Gotskii
Iogann Makhmastal'	Pavlin Vinogradov	**Kapitan Kanevskiy**	Kapitan Gavrilov
Irbis	Yasnyi	**Kapitan Khlebnikov**	Kapitan Sorokin
IrtyshLes	IgarkaLes	**Kapitan Kiriy**	Nikolay Novikov
Isakogorka	Novaya Ladoga (Pr. 596)	**Kapitan Kobets**	Drogobych (Ocean A/B)
Isidor Barakhov	Sovetskaya Yakutiya	**Kapitan Kondratjev**	Kapitan Gotskii
Istra	IgarkaLes	**Kapitan Kosolapov**	Kapitan M. Izmailov
Ivan Bogun	Dmitry Donskoi	**Kapitan Kozlovskiy**	Kapitan Gavrilov
Ivan Bolotnikov	Spartak	**Kapitan Krems**	Kapitan Sakharov
Ivan Kireyev	Dmitriy Ovtsyn	**Kapitan Krutov**	Kapitan Chechkin
Ivan Kruzenshtern	Vasilii Pronchischev	**Kapitan Kudlay**	Mikhail Strekalovski
Ivan Makarjin	Mikhail Strekalovski	**Kapitan Lus**	Kapitan Lus
Ivan Moskvitin	Vasilii Pronchischev	**Kapitan Lyubchenko**	Nikolay Novikov
Ivan Papanin	Ivan Papanin	**Kapitan M. Izmailov**	Kapitan M. Izmailov
Ivan Shadr	Igor Grabar	**Kapitan Malakhov**	Kapitan Belousov
Ivan Strod	Sovetskaya Yakutiya	**Kapitan Mann**	Anatoliy Kolesnichenko
Ivan Susanin	Dmitry Donskoi	**Kapitan Mecaik**	Kapitan Yevdokimov
Ivan Syrykh	Nikolay Novikov	**Kapitan Milovzorov**	Nikolay Novikov

SHIP NAME	LISTED UNDER SERIES
Kapitan Mochalov	Nikolay Novikov
Kapitan Moshkin	Kapitan Yevdokimov
Kapitan Myshevskiy	Kapitan Gotskii
Kapitan Nazarjev	Mikhail Strekalovski
Kapitan Nevezhkin	Drogobych (Ocean A/B)
Kapitan Nikolayev	Kapitan Sorokin
Kapitan Panfilov	Kapitan Panfilov
Kapitan Plakhin	Kapitan Chechkin
Kapitan Ponomaryov	Pavlin Vinogradov
Kapitan Primak	Kapitan Goncharov
Kapitan Sakharov	Kapitan Sakharov
Kapitan Samoylenko	Nikolay Novikov
Kapitan Sergiyevskiy	Kapitan Sakharov
Kapitan Shevchenko	Nikolay Novikov
Kapitan Shevtsov	Drogobych (Ocean A/B)
Kapitan Sorokin	Kapitan Sorokin
Kapitan Sviridov	Mikhail Strekalovski
Kapitan Tsirul'	Mikhail Strekalovski
Kapitan Vakula	Mikhail Strekalovski
Kapitan Vasilevskiy	Nikolay Novikov
Kapitan Vodenko	Mikhail Strekalovski
Kapitan Voronin	Kapitan Belousov
Kapitan Yevdokimov	Kapitan Yevdokimov
Kapitan Zamyatin	Nikolay Novikov
Kapitan Zarubin	Kapitan Chechkin
Kapitan Zavenyagin	Kapitan Yevdokimov
Kapitan Zheltovskiy	Kapitan Sakharov
Karaga	Krymsk
Katangli	Krymsk
Katmai Bay	Katmai Bay
Kavalerovo	Krymsk
Kem'	SibirLes
Kemerovo	Norilsk (a.k.a. SA-15)
Khariton Laptev	Vasilii Pronchischev
Kharlov	Mirnyy
Khatanga	BelomorskLes
Kholmsk	BelomorskLes
Kiev	Moskva
Kiisla	Kiisla
Kikhchik	Mirnyy
Kimry	Mirnyy
Kingisepp	Mirnyy
Kirensk	Krymsk
Klavdia Yelanskaya	Mariya Yermolova
Kola	Norilsk (a.k.a. SA-15)
Kolguyev	LadogaLes
Kolya Myagotin	Pioner
Komandor	Komandor
KomiLes	VolgoLes
Komsomolets Sakhalina	Novaya Ladoga (Pr. 596)
Kondratiy Bulavin	Spartak
Konstantin Korshunov	Sovetskii Voin
Konstantin Petrovskiy	Nikolay Novikov
Konstantin Savelyev	Sovetskii Voin
Konstantin Shestakov	Sovetskii Voin
Konstantin Yuon	Igor Grabar

SHIP NAME	LISTED UNDER SERIES
Konstantinovka	Fastov
Kontio	Otso
Koporje	Mirnyy
Korsakov	SibirLes
Kosmonavt Pavel Beliayev	Kosmonavt Pavel Beliayev
Kosmonavt V. Patsayev	Kosmonavt Pavel Beliayev
Kosmonavt V. Volkov	Kosmonavt Pavel Beliayev
KostromaLes	LadogaLes
Kotlas	Partizansk
KotlasLes	KotlasLes
Kovdor	Povenets
Kozyrevsk	Mirnyy
Krasin	Yermak
Krasnoborsk	Mirnyy
Krasnopolye	Krymsk
Krasnoturjinsk	Krymsk
Krasnoyarsk	Mirnyy
Krymsk	Krymsk
Krystall	Krystall
Kulluk	Kulluk
Kuloy	Novaya Ladoga (Pr. 596)
Kulunda	Krymsk
Kuzma Minim	Dmitry Donskoi
Kuzminki	Mirnyy
Kuznetsk	Krymsk
Ladogales	LadogaLes
Lakhta	SibirLes
Lara Mikheyenko	Pioner
Lazurit	Almaz
Lena	Lena
Lenin	Lenin
Leningrad	Moskva
Leningradskiy Opolchenets	Sovetskii Voin
Leningradskiy Partizan	Sovetskii Voin
Libby G	Libby G
Ligovo	Mirnyy
Lomonosovo	Mirnyy
Louis S. St. Laurent	Louis S. St. Laurent
Lunni	Lunni
Lyonya Golikov	Pioner
Lyubov Orlova	Mariya Yermolova
Magadan	Mudyug
Maksim Ammosov	Sovetskaya Yakutiya
Marat Kazey	Pioner
Marinor	Marinor
Mariya Savina	Mariya Yermolova
Mariya Yermolova	Mariya Yermolova
Mary Christina	Mary Christina
Maymaksa	Novaya Ladoga (Pr. 596)
Mekhanik Brilin	Mekhanik Yartsev
Mekhanik Fomin	Mekhanik Yartsev
Mekhanik Gordienko	Nikolay Novikov
Mekhanik Kotsov	Mekhanik Yartsev
Mekhanik Makarjin	Mekhanik Yartsev
Mekhanik Pustoshnyi	Mekhanik Yartsev
Mekhanik Pyatlin	Mekhanik Yartsev

SHIP NAME	LISTED UNDER SERIES
Mekhanik Rybachuk	BelomorskLes
Mekhanik Yartsev	Mekhanik Yartsev
Mikhail Cheremnykh	Igor Grabar
Mikhail Kalinin	Mikhail Kalinin
Mikhail Kutuzov	Dmitry Donskoi
Mikhail Prishvin	Alexandr Fadeev
Mikhail Somov	Mikhail Somov
Mikhail Strekalovski	Mikhail Strekalovski
Mikhail Svetlov	Alexandr Fadeev
Mirnyi	Mirnyy
Miscaroo	Ikaluk
Molikpaq	Molikpaq
Monchegorsk	Norilsk (a.k.a. SA-15)
Moskva	Moskva
Mudyug	Mudyug
Murman	Povenets
Murmansk	Moskva
Nadym	Samotlor
Nagayevo	Ventspils
Nathaniel B. Palmer	Nathaniel B. Palmer
Nauka	Arcticshelf
Navarin	Kapitan Gotskii
NevaLes	LadogaLes
Nevelsk	Uglegorsk
Nikel	Norilsk (a.k.a. SA-15)
Nikolay Bauman	Spartak
Nikolay Dolinskiy	Vitalii Diakonov
Nikolay Kantemir	Uglegorsk
Nikolay Kolomeytsev	Dmitriy Ovtsyn
Nikolay Novikov	Nikolay Novikov
Nikolay Tikhonov	Kapitan Gavrilov
Nikolay Yemelyanov	Sovetskii Voin
Nikolay Yevghenov	Dmitriy Ovtsyn
Nikolayevsk	Mikhail Kalinin
Nikopol	Nikopol
Nina Kukoverova	Pioner
Nizhnevartovsk	Samotlor
Nizhneyarsk	Norilsk (a.k.a. SA-15)
Nogliki	Uglegorsk
Norilsk	Norilsk (a.k.a. SA-15)
Norse Mersey	
Novaya Ladoga	Novaya Ladoga (Pr. 596)
Novokubansk	Uglegorsk
Novy Donbass	Novy Donbass
Oden	Oden
Oderstern	Weserstern
Oka	Novaya Ladoga (Pr. 596)
Okha	Norilsk (a.k.a. SA-15)
Olenegorsk	Povenets
Olga Sadovskaya	Mariya Yermolova
Omolon	SibirLes
Orekhovo-Zuyevo	BelomorskLes
Orient Makarov	Uglegorsk
Otso	Otso
Otto Schmidt	Otto Schmidt
Palana	Mirnyy
Palanga	Petrozavodsk
Pandora II	Pandora II
Paramushir	Petrozavodsk
Pargolovo	Petrozavodsk
Paromay	Petrozavodsk
Partizansk	Partizansk
Pavel Bashmakov	Dmitriy Ovtsyn
Pavel Korchagin	Pioner Moskvy
Pavel Ponomaryov	Kapitan Gotskii
Pavel Shepelyov	Vitalii Diakonov
Pavel Vavilov	Mikhail Strekalovski
Pavlik Larishkin	Pioner
Pavlin Vinogradov	Pavlin Vinogradov
Pavlovo	Petrozavodsk
Pavlovsk	Sergei Kirov
Pechenga	Petrozavodsk
Perm'	Petrozavodsk
Pertominsk	Petrozavodsk
Pervouralsk	Mirnyy
Petrokrepost	Petrozavodsk
Petropavlovsk	Mikhail Kalinin
Petropavlovsk-Kamchatsk	Partizansk
Petrovskiy	Petrozavodsk
Petrozavodsk	Petrozavodsk
Pierre Radisson	Piere Radisson
Pioner	Pioner
Pioner Arkhangelska	Pioner Moskvy
Pioner Belorussii	Pioner Moskvy
Pioner Buryatii	Pioner Moskvy
Pioner Chukotki	Pioner Moskvy
Pioner Estonii	Pioner Moskvy
Pioner Kamchatki	Pioner Moskvy
Pioner Karelii	Pioner Moskvy
Pioner Kazakhstana	Pioner Moskvy
Pioner Kholmska	Pioner Moskvy
Pioner Kirghizii	Pioner Moskvy
Pioner Litvy	Pioner Moskvy
Pioner Moldavii	Pioner Moskvy
Pioner Moskvy	Pioner Moskvy
Pioner Nakhodki	Sestroretsk
Pioner Oneghi	Pioner Moskvy
Pioner Primorya	Sestroretsk
Pioner Rossii	Pioner Moskvy
Pioner Severodvinska	Pioner Moskvy
Pioner Slavyanki	Pioner Moskvy
Pioner Uzbekistana	Pioner Moskvy
Pioner Vladivostoka	Sestroretsk
Pioner Vyborga	Sestroretsk
Pioner Yakutii	Pioner Moskvy
Pioner Yu. Sakhalinska	Pioner Moskvy
Pionerskaya Zor'ka	Pioner
Platon Oiunskiy	Sovetskaya Yakutiya
Plesetsk	Petrozavodsk
Pobedino	BelomorskLes
Polar Circle	Polar Circle
Polar Duke	Polar Duke

SHIP NAME	LISTED UNDER SERIES
Polar Sea	Polar Star
Polar Star	Polar Star
Polarstern	Polarstern
Pomorje	Petrozavodsk
Ponoy	Petrozavodsk
Poronaysk	Petrozavodsk
Poronin	BelomorskLes
Posyet	Posiet
Povenets	Povenets
Primorje	Petrozavodsk
Professor Bubnov	Vitalii Diakonov
Professor Goryunov	Professor Goryunov
Professor Papkovich	Vitalii Diakonov
Professor Tovstykh	Kapitan Gavrilov
Professor Victor Vologdin	Vitalii Diakonov
Professor Vladimir Popov	Vitalii Diakonov
Professor Voskresenskiy	Vitalii Diakonov
Przhevalsk	Petrozavodsk
Pulkovo	Petrozavodsk
Pushlakhta	Petrozavodsk
Pustozersk	Petrozavodsk
Pyotr Kakhovski	Spartak
Pyotr Pakhtusov	Vasilii Pronchischev
Pyotr Smidovich	Nikolay Novikov
Pyotr Strelkov	Nikolay Novikov
Pyotr Velikiy	Dmitry Donskoi
Radon	Yasnyi
Raychikhinsk	BelomorskLes
Rheinstern	Rheinstern
Roschino	Partizansk
Rossia	Arktika
Rubin	Almaz
Sakhalin-1	Sakhalin-1
Sakhalin-10	Sakhalin-1
Sakhalin-2	Sakhalin-1
Sakhalin-3	Sakhalin-1
Sakhalin-4	Sakhalin-1
Sakhalin-5	Sakhalin-1
Sakhalin-6	Sakhalin-1
Sakhalin-7	Sakhalin-1
Sakhalin-8	Sakhalin-1
Sakhalin-9	Sakhalin-1
SakhalinLes	BelomorskLes
Salavat Yulayev	Spartak
Saldus	LadogaLes
Samotlor	Samotlor
Sasha Borodulin	Pioner
Sasha Kondratyev	Pioner
Sasha Kotov	Pioner
Seapower	Seapower
SelengaLes	BelomorskLes
Semyon Dezhnev	Vasilii Pronchischev
Sergei Kirov	Sergei Kirov
Serghey Kravkov	Dmitriy Ovtsyn
Sernovodsk	Sosnovets
Sestroretsk	Sestroretsk
SevMorPut	SevMorPut
Shadrinsk	BelomorskLes
Shatura	BelomorskLes
Shiraze	Shiraze
Shkotovo	Partizansk
Shuhle Geteborg	Shuhle Geteborg
Shura Kober	Pioner
Shushenskoye	Mirnyy
Sibir	Arktika
SibirLes	SibirLes
Sibirski 2101	Sibirski
Sibirski 2102	Sibirski
Sibirski 2103	Sibirski
Sibirski 2104	Sibirski
Sibirski 2105	Sibirski
Sibirski 2106	Sibirski
Sibirski 2107	Sibirski
Sibirski 2108	Sibirski
Sibirski 2109	Sibirski
Sibirski 2121	Sibirski
Sibirsky	Stroptivyi
Sibirtsevo	SibirLes
Sisu	Atle
Slautnoye	Sosnovets
Slavyanka	Posiet
Snezhnogorsk	Sosnovets
Snow Dragon	Ivan Papanin
Sofiysk	Sosnovets
Sofja Perovskaya	Mirnyy
Sosnovets	Sosnovets
Sovetskiy Moryak	Sovetskii Voin
Sovetskiy Pogranichnik	Sovetskii Voin
Sovetskiy Soyuz	Arktika
Sovietskaya Yakutiya	Sovetskaya Yakutiya
Sovietskiy Voin	Sovetskii Voin
Spartak	Spartak
Spravedlivyy	Stroptivyi
Stakhanovets	Stroptivyi
Stakhanovets Kotov	Stakhanovets Kotov
Stakhanovets Yermolenko	Stakhanovets Kotov
Stepan Krashennikov	Vitus Bering
Stepan Malyghin	Dmitriy Ovtsyn
Stepan Razin	Dmitry Donskoi
Stepan Savushkin	Krymsk
Stroptivyi	Stroptivyi
SukhonaLes	SukhonaLes
Surgut	Sosnovets
Suvorovets	Stroptivyi
Svetlomor-1	Svetlomor-1
Svetlomor-3	Svetlomor-1
Svirsk	Povenets
Svobodnyi	Partizansk
Tampere	Mirnyy
Tayga	BelomorskLes
Taymyr	Taimyr
Tebo Olimpia	Tebo Olimpia

SHIP NAME	LISTED UNDER SERIES
Teodor Nette	Pavlin Vinogradov
Terney	SibirLes
Terry Fox	Terry Fox
Thuleland	Thuleland
Tikhon Kiselyov	Kapitan Gavrilov
Tiksi	Norilsk (a.k.a. SA-15)
Tim Bak	Mikhail Strekalovski
Tobol	Mirnyy
Tolya Bodarchuk	Pioner
Tolya Komar	Pioner
Tolya Shumov	Pioner
Topaz	Almaz
Trans Dania	Trans Dania
Turku	Mirnyy
Tymovsk	Krymsk
Uglegorsk	Uglegorsk
Uikku	Uikku
Ulan-Ude	BelomorskLes
Umka	Yasnyi
Ural	Arktika
Urengoy	Samotlor
Urho	Atle
Usinsk	Samotlor
Ussuri	Povenets
Ussurijsk	Ventspils
Vaga	Mirnyy
Valentin Shashin	Valentin Shashin
Valerian Albanov	Dmitriy Ovtsyn
Valeriy Kuzmin	Vitalii Diakonov
Valeriy Volkov	Pioner
Valya Kotik	Pioner
Vanino	Vanino
Vasilii Pronchischev	Vasilii Pronchischev
Vasiliy Fedoseyev	Kapitan Gotskii
Vasilliy Burkhanov	Anatoliy Kolesnichenko
Vasilliy Golovnin	Vitus Bering
Vasilliy Musinskiy	Nikolay Novikov
Vasya Alekseyev	Novaya Ladoga (Pr. 596)
Vasya Korobko	Pioner
Vaygach	Taimyr
Velikiy Ustyug	Mirnyy
Ventspils	Ventspils
Vera Mukhina	Igor Grabar
Victor Tkachev	Mikhail Strekalovski
Viirelaid	Viiralaid
Viluysk	Samotlor
Vitaliy Diakonov	Vitalii Diakonov
Vitus Bering	Vitus Bering
Vitya Chalenko	Pioner
Vitya Khomenko	Pioner
Vitya Sitnitsa	Pioner
Vladimir Arsenjev	Vitus Bering
Vladimir Mordvinov	Nikolay Novikov
Vladimir Sukhotskiy	Dmitriy Ovtsyn
Vladimir Timofeyev	Nikolay Novikov
Vladivostok	Moskva
Vlas Nichkov	Nikolay Novikov
Vohilaid	Vohilaid
VolgoLes	VolgoLes
Volodya Sherbatsevich	Pioner
Voskresensk	BelomorskLes
Vostok-2	Novaya Ladoga (Pr. 596)
Vyacheslav Denisov	Sovetskii Voin
VyatkaLes	SibirLes
Vyborgskaya Storona	Sovetskii Voin
Vysokogorsk	Igor Ilyinski
Vzmorje	SibirLes
Weserstern	Weserstern
World Discoverer	World Discoverer
Yakob Kunder	Sovetskii Voin
Yakov Reznichenko	Sovetskii Voin
Yakov Smirnitskiy	Dmitriy Ovtsyn
Yamal	Arktika
Yana	SibirLes
Yantarnyi	Mirnyy
Yasnyi	Yasnyi
Yekaterina Belashova	Igor Grabar
Yelena Shatrova	Igor Ilyinski
Yemeljan Pugachyov	Dmitry Donskoi
Yemer	Atle
Yeniseysk	Samotlor
Yermak	Yermak
Yerofey Khabarov	Vasilii Pronchischev
Yevgeniy Chaplanov	Krymsk
Yevgeniy Nikonov	Sovetskii Voin
Yuriy Arshenevskiy	Anatoliy Kolesnichenko
Yuriy Dolgorukiy	Dmitry Donskoi
Yuriy Lisyanskiy	Vasilii Pronchischev
Yuriy Savinov	Nikolay Novikov
Yuta Bondarovskaya	Pioner
Yuvent	Ivan Papanin
Zabaykalsk	BelomorskLes
Zina Portnova	Pioner
Zolotitsa	Novaya Ladoga (Pr. 596)

SHIPS BY SERIES

Alphabetical listing of ships, grouped by the name of the first ship in a series.

SERIES ENTRY LAYOUT

SERIES NAME			SERIES SIZE		ICE CLASS		ICE RANK
LOA	Bmold	DEPTH	PROP MAC	PROP # / POWER DIS	NOM. SPEED	BOW SHAPE	SHIP TYPES
LBP	Bmax	GROSS	PWR@prop	PROP. TYPE	RANGE	STEM ANGLE	
Dwl	DISPL	DWT	PWR@mach	# OF BLADES / DIAM	FUEL CAP	CREW	
arc	arc	arc	BLRD.THRUST	NOZZLES?	FUEL RATE	THRUSTERS?	
max	max	max	ICEBREAKING CAPABILITY				

(CARGO CAP./HANDLING) (UNLOADING EQUIPMENT) (HELICOPTER AVAILABILITY) (NOTES)

(AUX. ICEBREAKING SYST.)(SERIES MODIFICATIONS) (SPECIAL FEATURES) (REFERENCES)

SHIP ENTRY LAYOUT

SHIP NAME	FORMER NAMES		First?	ICE REG	REG	LLOYD REG#
SHIP OWNER		HOME PORT		FLAG		
SHIPYARD AND YEAR OF CONSTRUCTION		(MODERNIZATION)		(NOTES)		
(SPECIAL FEATURES)		(CHARTER RATE AND OP. COSTS)				

EXPLANATION OF CODES

BOW SHAPE CODES

CONC	Conventional wedge with curvilinear line stem and bottom stopper
CONS	Conventional plain wedge with straight-line stem and bottom stopper
CONV	Conventional plain wedge with straight-line stem
SLED	Sledge shaped
SLOP	Sloped plane with wedge
SPOO	Spoon-shaped
THYS	Thyssen-Waas

PROP MACHINERY CODES

DIEL	Diesel-electric
MSDG	Medium-speed Diesel-geared
NPTE	Nuclear-powered Turbo-electric
SSDG	Slow-speed Diesel-geared
TUEL	Turbo-electric

SHIP TYPE CODES

ASRV	Antarctic supply research vessel
BULK	Bulk carier
CGIB	Coast Guard icebreaker
CHEM	Chemical transport
CONT	Container carrier
DRED	Dredge
DRIR	Drilling rig
DRIS	Drilling ship
FERR	Ferry
HLV	Heavy lift vessel
IB	Purpose Icebreaker
LASH	LASH & container carrier
MPC	Multi-purpose cargo
MPIB	Multi-purpose icebreaker
MSH	Mother ship for submersibles
OTHE	Other type
PASS	Passenger
PATR	Patrol boat
PIB	Polar icebreaker
REFR	Refrigerator
RIB	River icebreaker
RORO	Roll on - Roll off
RV	Research vessel
SALV	Salvage tug
SUBM	Submersible
SUPP	Supply ship
SWIB	Shallow-water icebreaker
TANK	Tanker

Akademik Fedorov			1 ships			ULA		rank: 2
141.20	23.21	13.30	DIEL	1		16.0	CONS	RV
128.60	23.50	13000	14000	FPP		80days		SUPP
			16500	4	5.1	1900 t.	90	
							Thrusters	
8.50	10000	7600	1m @ 2kn					

cranes: 2@50 t. 2@10 t., 2 tractors for cargo transport on ice.

23x23m. landing pad and 6x6x21 m. hangars for two helicopters Mi-8 and Ka-32

Hull is coated with low-friction and anti-fouling coating "Reapox-LV". Diving station available. Bow & stern thrusters. 40 double-occupancy passenger cabins.

Andryushin.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Akademik Fedorov Rauma-Repola Oy			1987	First	RR Russian Federation		

Akademik Nalivkin					UL		rank: 3
81.85	14.83	7.50		1	14.5	—	
73.50		2833	3090	CPP	12000 n. mi.		
—			—	—	—	31	
5.00		1313	—	Nozzles	—	—	
—			—	—	—	—	

Crew: 31 + 29 scientists

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Akademik Nalivkin SoyuzMorGeo Schetsyn Shipyard		Baku	1988		RR Azerbaidjan		

Akademik Sergei Vavilov	2 ships	L1	rank: 4

117.10	18.20	10.00
110.50		6231
5.90	6600	2275

MSDG	2		CONV
	CPP		50
2570	4		128
			Thrusters

Scientists included in the number of crew.

Bow thruster, azimuthing stern thruster @700kW.

Sheidorov, 1990.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Akademik Ioffe Academy of Sciences of Russian Federation Hollming Oy-Rauma		Kaliningrad Fitted with wind-assisted drive.	1989		RR Russian Federation		
Akademik Sergei Vavilov Academy of Sciences of Russian Federation Hollming Oy-Rauma		Kaliningrad	1989	First	RR Russian Federation		

Aleksandr Dovzhenko			5 ships		L1		rank: 4
100.54		6.80	SSDG	1	13.7	CONV	TIMB
91.08	14.36	2718	1910	FPP	6000n.mi		
			2130	4		24	
5.77	5469	3370					

2970 t.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Aleksandr Dovzhenko			1965	First			

Aleksandr Kaverznev							IA		rank: 4
129.65		8.75	SSDG	1		14.3		CONV	CHEM
126.76	19.04	5712		CPP		5500n.mi		45	TANK
6.95		8661	4260	4	4.1			18	
								Thrusters	

11108.4 m^3 total

Bow thruster. Petrakov.

SISTER SHIPS

SHIP NAME	FORMER NAMES		YR BUILT	First?	ICE RE	REG	LLOYD REG#
SHIP OWNER		HOME PORT			FLAG		
SHIPYARD		(MODERNIZATION)			(NOTES)		
(SPECIAL FEATURES)		(CHARTER RATE AND OP. COSTS)					
Aleksandr Kaverznev			1981	First	DNV		
Latvian Shipping Co.		Riga					
Oskapshamn							

Alexandr Fadeev	5 ships	L1	rank: 4

129.40		10.43
118.19	19.24	6478
—		
—		
7.48	11640	6283

SSDG	1	17.5	CONV	CONT
4040	FPP	12000n.mi		
4490	4		24	
—	—	—	—	

5624 t., cranes: 1@500 t.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Aleksandr Fadeyev Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1973	First	RR Russian Federation		
Aleksandr Prokofyev Baltic Shipping Co.		St. Petersburg	1975		RR Russian Federation		
Aleksandr Tvardovskiy Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1974		RR Russian Federation		
Mikhail Prishvin Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1974		RR Russian Federation		
Mikhail Svetlov Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1973		RR Russian Federation		

A'exey Kosygin | **4 ships** | **L1** | **rank: 4**

262.85	32.20	18.30	SSDG	2	17.5	CONS	LASH
232.81		37464	24700	FPP	12000n.mi	36	
			27200	4 5.6		39	
11.65	62038	40880					

30340t; cont: 776@20' or 48 lighters in holds, 704 20' cont. + 34 lighters 18.75x9.5x4.4 m. on deck. Derrick on the upper deck can lift 500 t. lighters up to 25.8 m. above inner bottom.

Bow structures, rudder, propeller and shafting are strengthened to UL class.

Bognenko.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES / HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Aleksey Kosygin Far-Eastern Shipping Co. / Vladivostok Kherson Shipyard	 Vladivostok	1983	First	RR Russian Federation		8227460

Almaz			**7 ships**		**UL**		**rank: 3**
58.55	12.68	6.02	DIEL	1	13.0	_	SALV
51.62		1074	1900	_	_	_	TUG
4.61		440	_	4	_	Thrusters	
_			_	_	_		

Bow thrusters.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Almaz Kamchatka Shipping Co.		Petropavlovsk-Kamchatskiy	1976	First	RR Russian Federation		
Atlas Sakhalin Shipping Co.		Korsakov	1987		RR Russian Federation		
EPRON Baltic Shipping Co.		St. Petersburg	1983		RR Russian Federation		
Kapitan Beklemishev Baltic Shipping Co.		St. Petersburg	1985		RR Russian Federation		
Lazurit Far-Eastern Shipping Co. / Vladivostok		Vladivistok	1990		RR Republic of China		
Rubin Sakhalin Shipping Co.		Korsakov	1982		RR Russian Federation		
Topaz Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1984		RR Russian Federation		

Almirante Irizar		1 ships				rank: 1
119.30		DIEL	2	18.5	CONC	CGIB
—	25.00	11910	FPP	—	22	
9.50	11810	14350	4	—	133	
—		138	—	—	—	
	14900					

Dick.

SISTER SHIPS

SHIP NAME	FORMER NAMES		YR BUILT	First?	ICE RE	REG	LLOYD REG#
SHIP OWNER		HOME PORT			FLAG		
SHIPYARD		(MODERNIZATION)			(NOTES)		
(SPECIAL FEATURES)		(CHARTER RATE AND OP. COSTS)					
Almirante Irizar			1978	First			
					Argentina		
Kvaerner Masa-Yards							

Anatoliy Kolesnichenko			5 ships			ULA			rank: 2
173.50	24.50	15.20	MSDG	1		17.0	CONS	BULK	
164.90	24.54	18574	13600	CPP		12000n.mi	30	MPC	
8.50	24100	12450	15400	4	5.6	—	44	RORO	
9.00	25900	14250	160	—		—	—		
10.50	31200	19550	1.0m.@2 kn.						

12200 t., cont: 576@20'(40'), incl. 50 refr., cranes: 5

This series is a modification of the "Norilsk" Series. Modifications include: further strenghening of stem and bow bottom and stern plating, and increasing of deadweight and cargo capacity.

Semenov.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Anatoliy Kolesnichenko Far-Eastern Shipping Co. / Vladivostok Valmet Oy Helsingin Telakka		Vladivostok	1985	First	RR Russian Federation		8406688
Kapitan Danilkin Murmansk Shipping Co.		Murmansk	1987		RR Russian Federation		
Kapitan Mann Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1985		RR Russian Federation		
Vasilliy Burkhanov Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1986		RR Russian Federation		
Yuriy Arshenevskiy Murmansk Shipping Co.		Murmansk	1986		RR Russian Federation		

Anna Akhmatova			UL		rank: 3
88.00	17.20	7.40	_	1	14.0
78.00	17.20	4575	_	_	2000
_			3200	_	_
_			_	_	208 g/kW-hr
_			750 t., 150 pass. + 90 seats		

_			
22			
_			

Bow & stern thrusters.

SISTER SHIPS

SHIP NAME	FORMER NAMES		YR BUILT	First?	ICE RE	REG	LLOYD REG#
SHIP OWNER		HOME PORT			FLAG		
SHIPYARD		(MODERNIZATION)			(NOTES)		
(SPECIAL FEATURES)		(CHARTER RATE AND OP. COSTS)					
Anna Akhmatova			1988		RR		
Ministry of Gas Industry of the Russian Federation					Russian Federation		
Stocznia im. Komuny Pariskiej Gdynia							

Anna Karenina			1 ships		L1		rank: 4
145.19	25.20	13.29		2	17.5	—	FERR
131.27	25.51	14213	19124	CPP	—	—	PASS
5.29		2830	—	—	—	—	RORO
—			—	—	—	—	

425 cars, 54 trucks. Bow door & ramp 11.3x8.0, stern door & ramp 11.2x10.60.

2 bow thrusters.

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Anna Karenina Rigorous Shipping Co. Ltd. Wartsilla Shipyards	Baltika, Viking Song	Limassol	1980	First	RR Cyprus		

Aranda			IA Super				rank: 3
	13.60	6.70	SSDG	1			RV
59.00	13.80	1734		CPP			
4.60	1800		3000	4		12	
				Nozzles			

Hangar & elevator for 2 helicopters.

Bow & stern thrusters @400 kW & 150 kW.

Room for reseарach team of 25

SISTER SHIPS

SHIP NAME	FORMER NAMES		YR BUILT	First?	ICE RE	REG	LLOYD REG#
SHIP OWNER		HOME PORT			FLAG		
SHIPYARD		(MODERNIZATION)			(NOTES)		
(SPECIAL FEATURES)		(CHARTER RATE AND OP. COSTS)					
Aranda			1989	First	FR		8802076
Finnish Board of Navigation		Helsinki			Finland		
Wartsilla Shipyards							

Arctic		
220.85	22.86	15.20
206.20	22.90	20117
10.50		26440
11.07	38466	28400

1 ships **2** **rank: 2**

MSDG	1	16.5	CONC	BULK
8800	CPP	—	30	TANK
10800	4 5.2	—	46	
155	Nozzles	—	—	
1.0 @ 2kn				

cranes: 4@20 t., 5 pumps

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Arctic The Royal Trust Co. Port Weller Dry Docks Ltd.		Ottawa	1978	First	CR Canada	LR	7517507

Arctic Tuktu						A		rank: 3
—	11.58	4.57	—	—	—	—		SUPP
48.67		719	—	—	—	—		
4.06			2350	4	—	—		
—			—	—	—	—		

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Arctic Tuktu Star Shipyard Ltd.	Mary B.	Edmonton	1972		ABS U.S.A.		7207310

Arcticshelf	UL	rank: 4

—	—	—	—
—	—	—	—
—	—	—	—
—	—	—	—

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Arcticshelf							
Nauka Equipped for drilling in deep sea up to 5000 m. depth.							

Arktika			6 ships			LL1		rank: 1
148.00	28.00	17.20	NPTE	3	1:1:1	20.8	CONS	IB
136.00	30.00	18172	49000	FPP		Unlimited	24	
11.00	23460		55100	4	5.3	—	145	
—			480	—		—	—	
		4096	2.25m @ ~2kn					

cranes: 2@3 t.

"Ural", the sixth ship in a series is under construction, to be commissioned in 1995.

Tsoy (1992); Tsoy (1993); Tsoy (1990); Wind.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Arktika Murmansk Shipping Co. Admiralty Ship Yard	Leonid Brezhnev	Murmansk	1974	First	RR Russian Federation Sixth ship in a series is under construction as of 4/94.		7429061
Rossia Murmansk Shipping Co. Admiralty Ship Yard		Murmansk	1985		RR Russian Federation		
Sibir Murmansk Shipping Co. Admiralty Ship Yard		Murmansk	1977		RR Russian Federation		
Sovetskiy Soyuz Murmansk Shipping Co. Admiralty Ship Yard		Murmansk	1989		RR Russian Federation		
Ural Admiralty Ship Yard					 Russian Federation		
Yamal Murmansk Shipping Co. Admiralty Ship Yard		Murmansk	1992		RR Russian Federation		

Atle			5 ships				rank: 1
104.60		12.10	DIEL	4	18.0	CONS	IB
96.00	23.80	6844	16170	FPP		20	
7.30	8000		18380	4		54	
			191				
8.30	9500		1.1m @ 2kn				

props: 2 aft & 2 fore

Dick.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Atle The National Maritime Administration of Sweden Wartsilla Shipyards		Norrkoping	1974	First	Sweden		7347627
Frej Wartsilla Shipyards			1975		Sweden		
Sisu Wartsilla Shipyards			1976		Finland		
Urho Finnish Board of Navigation Oy Wartsila Ab		Helsinki	1975	First	DNV Finland	FR	7347615
Yemer Wartsilla Shipyards			1977		Sweden		

Aurora Austrelis			1 ships		2		rank: 3
94.90	20.30	13.25	MSDG	1	13.0	—	IB
88.40		6574	10000	CPP	24000 m. mi.		RV
7.85		3500	—	—	—	24	SUPP
—			—	—	—	—	
			1.2 m. @2.5 kn.				

1600 m^3., tanks 1000 m^3.

Hangar for 2 Seahawk helicopters.

Crew of 29 +109. Bow and stern are strengthened to CASPPR ice class 3.

Double-hull design.

Bow thrusters @800kW. 2 retractable, azimuthing stern thrusters @400 kW each.

SISTER SHIPS

SHIP NAME	FORMER NAMES		YR BUILT	First?	ICE RE	REG	LLOYD REG#
SHIP OWNER		HOME PORT			FLAG		
SHIPYARD		(MODERNIZATION)			(NOTES)		
(SPECIAL FEATURES)		(CHARTER RATE AND OP. COSTS)					
Aurora Austrelis					CR	LR	
Antarctic Shipping Pty. Ltd.		Hobart, Tas.			Austrelia		

Balkhash	3 ships	L1	rank: 4

72.15		5.00
65.40	11.32	1124
—		
—		
4.35	2257	1367

MSDG	1	11.5	CONV	TIMB
660	FPP	3000n.mi	—	
735	4	—	21	
—	—	—	—	

1210 t.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Bakhchisaray Northern Shipping Company		Arkhangelsk	1971		RR Russian Federation		
Balkhash Murmansk Shipping Co.		Murmansk	1969	First	RR Russian Federation		
Belomorye Northern Shipping Company		Arkhangelsk	1970		RR Russian Federation		

Baltic Press	2 ships		IA		rank: 4
135.85 16.50 10.90	—	—	13.5	—	CONT
128.35 16.79 1366	—	—	—	—	RORO
4.45 4450	2647	4	—	—	
4.60	—	—	—	—	

cont: 249@20'

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Baltic Press Ture TA Axelsson		Skarhamn		0	ABS Sweden		7802067
Baltic Print Ture TA Axelsson Karlskronavarvet A/B		Skarhamn			ABS		7902861

BelomorskLes	29 ships	L1	rank: 4

123.88	16.70	8.45	SSDG	1	16.0	CONV	TIMB
115.00		4519	3600	FPP	6000n.mi		
			4010	4		25	
6.82	9220	5726					

4973 t., cranes: 1@40 t. 1@15 t. 8 @10 t.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
AltayLes Sakhalin Shipping Co.		Kholmsk	1963		RR Russian Federation		
Baykonur Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1967		RR Russian Federation		
BelomorskLes Northern Shipping Company Stocznia Gdanska im. Lenina		Arkhangelsk	1962	First	RR Russian Federation		5040122
Darasun Sakhalin Shipping Co.		Kholmsk	1967		RR Russian Federation		
Dzhurma Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1968		RR Russian Federation		
Elektrostal' Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1966		RR Russian Federation		
Kansk Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1967		RR Russian Federation		
Khatanga Sakhalin Shipping Co.		Kholmsk	1968		RR Russian Federation		
Kholmsk Sakhalin Shipping Co.		Kholmsk	1965		RR Russian Federation		
Mekhanik Rybachuk Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1963		RR Russian Federation		
Orekhovo-Zuyevo Sakhalin Shipping Co.		Kholmsk	1966		RR Russian Federation		

Pobedino		1967	RR
Sakhalin Shipping Co.	Kholmsk		Russian Federation
Poronin		1967	RR
Sakhalin Shipping Co.	Kholmsk		Russian Federation
Raychikhinsk		1967	RR
Sakhalin Shipping Co.	Kholmsk		Russian Federation
SakhalinLes		1963	RR
Sakhalin Shipping Co.	Kholmsk		Russian Federation
SelengaLes		1963	RR
Northern Shipping Company	Arkhangelsk		Russian Federation
Shadrinsk		1967	RR
Far-Eastern Shipping Co. / Vladivostok	Vladivostok		Russian Federation
Shatura		1966	RR
Sakhalin Shipping Co.	Kholmsk		Russian Federation
Tayga		1964	RR
Kamchatka Shipping Co.	Petropavlovsk-Kamchatskii		Russian Federation
Ulan-Ude		1968	RR
Sakhalin Shipping Co.	Kholmsk		Russian Federation
Voskresensk		1966	RR
Sakhalin Shipping Co.	Kholmsk		Russian Federation
Zabaykalsk		1967	RR
Sakhalin Shipping Co.	Kholmsk		Russian Federation

Canmar Explorer			2 ships		IAA		rank: 3
	30.48	8.71			10.0		DRIS
109.19		6041	—	—	—	—	
6.76	12445	6419	2206	4	—	—	
—			—	—	—	—	
—							

cranes: 1@80 t. 1@35 t. 1@30 t.

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Canmar Explorer Canadian Marine Drilling Southeastern SB Corp.	Snakehead ('76)	Halifax,N.S. Widened by addition of sponsons 130'x15'x26.37', istalled by Purvis Navcon Shipyard Ltd., Canada, 1980.	1945		ABS U.S.A.		4507870
Canmar Explorer II Canadian Marine Drilling J. A. Jones Construction Co. Inc.	Mooring Hitch ('76)	Halifax,N.S. Widened by addition of sponsons 130'x15'x26.37', istalled by Purvis Navcon Shipyard Ltd., Canada, 1980.	1945		ABS U.S.A.		4505915

Canmar Kigiriak	1 ships	4	rank: 1

91.00	17.85	10.04	SSDG	1	18.8	SPOO	IB
78.90	19.31	3642	12800	CPP	—	24	SUPP
—	7806	2066	—	4 5.1	—	—	TUG
8.50	8550		162	Nozzles	—	—	
			1.5 m.@3kn				

Dick.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Canmar Kigiriak Amoco Canada Research Ltd. St. John SB & Dry Dock Co.		Vancouver, BC.	1970	First	CR Canada		7305280

Discoverer 534							IA	rank: 4
162.69	24.38	9.75		—	10.0	—	DRIS
148.14	24.49	12011	11765	—	—	—	
7.35	20562	7286	16047	4	—	—	
—			—	—	—	—	

cranes: 2@42 t. 2@3 t.

Bow and stern thrusters added

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Discoverer 534 Mitsui SB & Engineering Co.,Ltd.		Panama Bow and stern thrusters added			ABS Panama		7509378
Discoverer Seven Seas Deep Ocean Drilling Inc. Mitsui SB & Engineering Co.,Ltd.		Panama			ABS Panama		7611561

Discovery			IA				rank: 4
	12.80	5.79					RV
74.93		2038					
5.06				4			

SISTER SHIPS

SHIP NAME	FORMER NAMES		YR BUILT	First?	ICE RE	REG	LLOYD REG#
SHIP OWNER		HOME PORT			FLAG		
SHIPYARD		(MODERNIZATION)			(NOTES)		
(SPECIAL FEATURES)		(CHARTER RATE AND OP. COSTS)					
Discovery					ABS		7406475
		Panama					
Burrard Dry Dock Co.Ltd.							

Dmitriy Ovtsyn			13 ships		UL		rank: 3
66.83	11.87	6.02	SSDG		13.8	CONV	RV
60.00	11.92	1134	1618	FPP			
				4			
4.12		639	13				

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES / HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Dmitriy Ovtsyn Oy Laivateollisuus Ab		1970	First	RR Russian Federation		7019074
Dmitriy Sterlegov Tiksi Hydrography		1971		RR Russian Federation		
Eduard Toll Tiksi Hydrography		1972		RR Russian Federation		
Fyodor Matisen Providenie Hydrography		1976		RR Russian Federation		
Ivan Kireyev Arkhanghelsk Hydrography		1977		RR Russian Federation		
Nikolay Kolomeytsev Arkhanghelsk Hydrography		1972		RR Russian Federation		
Nikolay Yevghenov Igarka Hydrography		1972		RR Russian Federation		
Pavel Bashmakov Arkhanghelsk Hydrography		1977		RR Russian Federation		
Serghey Kravkov Arkhanghelsk Hydrography		1974		RR Russian Federation		
Stepan Malyghin Providenie Hydrography		1971		RR Russian Federation		
Valerian Albanov Arkhanghelsk Hydrography		1977		RR Russian Federation		

Vladimir Sukhotskiy Tiksi Hydrography	1973	RR Russian Federation
Yakov Smirnitskiy Arkhanghelsk Hydrography	1977	RR Russian Federation

Dmitry Donskoi			13 ships		UL		rank: 3
162.10	22.86	13.50	SSDG	1	15.2	CONV	BULK
154.88	22.92	13567	7430	FPP	6000n.mi		
9.02		19590	8240	4	—	25	
			—	—	—	—	
9.88	27340	19885					

18737 t., 22257 m^3, cont: 442@20'

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Admiral Ushakov Murmansk Shipping Co. VEB Warnemuende		Murmansk	1979		RR Russian Federation		
Aleksandr Nevskiy Murmansk Shipping Co. VEB Warnemuende		Murmansk	1978		RR Russian Federation		
Aleksandr Suvorov Murmansk Shipping Co. VEB Warnemuende		Murmansk	1979		RR Russian Federation		
Dmitriy Pozharskiy Murmansk Shipping Co. VEB Warnemuende		Murmansk	1978		RR Russian Federation		
Dmitry Donskoi Murmansk Shipping Co.		Murmansk	1977	First	RR Russian Federation		7721196
Ivan Bogun Murmansk Shipping Co. VEB Warnemuende		Murmansk	1981		RR Russian Federation		
Ivan Susanin Murmansk Shipping Co. VEB Warnemuende		Murmansk	1981		RR Russian Federation		
Kuzma Minim Murmansk Shipping Co. VEB Warnemuende		Murmansk	1980		RR Russian Federation		
Mikhail Kutuzov Murmansk Shipping Co. VEB Warnemuende		Murmansk	1979		RR Russian Federation		
Pyotr Velikiy Murmansk Shipping Co. VEB Warnemuende		Murmansk	1978		RR Russian Federation		
Stepan Razin Murmansk Shipping Co. VEB Warnemuende		Murmansk	1980		RR Russian Federation		

Yemeljan Pugachyov Murmansk Shipping Co. VEB Warnemuende	Murmansk	1980	RR Russian Federation
Yuriy Dolgorukiy Murmansk Shipping Co. VEB Warnemuende	Murmansk	1980	RR Russian Federation

Drogobych (Ocean A/B) UL rank: 3

116.08	16.30	7.83
106.00		4198
6.67		5780
—		

MSDG	—	13.0	—	TANK
—	—	—	—	
2574	—	—	—	
—	—	—	—	

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Drogobych SICO Ltd.	Ocean A, Ocean B	Kingston	1972		The Grenadines		
Kapitan Djachuk Primorsk Shipping Co. Georgi Dimitrov Shipyard		Nakhodka	1975		RR Russian Federation		
Kapitan Dotsenko Primorsk Shipping Co.		Nakhodka	1975		RR Russian Federation		
Kapitan Kobets Primorsk Shipping Co.		Nakhodka	1976		RR Russian Federation		
Kapitan Nevezhkin Primorsk Shipping Co.		Nakhodka	1976		RR Russian Federation		
Kapitan Shevtsov Primorsk Shipping Co.		Nakhodka	1973		RR Russian Federation		

Dunker			IA		rank: 4
10.00 5.30	MSDG		12.5		TUG
30.00	2680				
	39				
4.70					

SISTER SHIPS

SHIP NAME	FORMER NAMES		YR BUILT	First?	ICE RE	REG	LLOYD REG#
SHIP OWNER		HOME PORT			FLAG		
SHIPYARD		(MODERNIZATION)			(NOTES)		
(SPECIAL FEATURES)		(CHARTER RATE AND OP. COSTS)					
Dunker					LR		

Emsstern	2 ships	E3	rank: 4

110.00	17.70	10.60	SSDG	1	12.5	CONV	
124.00		6262	3600	CPP	5000 mi.	45	
—			—	— 3.1	—	19	
8.54		10650	—	—	—	—	
—			—	—	—	—	
—							

10000 m^3.

Double-hull design.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Elbestern Rigel Schiffahrts MTW Schiffbau Werft			1992	First	GL Germany		
Emsstern Rigel Schiffahrts MTW Schiffbau Werft			1992	First	GL Germany		

Fastov			**2 ships**		**L1**		**rank: 4**
121.82	17.59	9.91	—	—	15.0	CONV	MPC
113.44	17.61	5583	3972	4	—	—	
—		7810	—	—	—	—	
7.72					—	—	

cont: 258@20'

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Fastov Murmansk Shipping Co. Veb Shiftswerft Neptun	Gaviota ('85), Gaviota II ('83)	Murmansk	1979	First	RR Russian Federation		7932692
Konstantinovka Murmansk Shipping Co.		Murmansk	1981		RR Russian Federation		

Fennica			**2 ships**			**Polar-10**		**rank: 2**
116.00	26.00	12.50	DIEL	2		16.0	SPOO	IB
—			15000	APD		—	—	SUPP
7.00	4800	1650	21000	4	4.2	—	—	SWIB
8.00		3900	234	Nozzles		—	Thrusters	
8.40		4800	0.8 m.@8 kn, 1.8 m.@2 kn.					

cranes: 1@120 t.@8.2 m., 1@15 t.@14 m. 1@5 t.@30 m.

Helicopter, hangar & elevator available

A second ship in the series is to be commissioned in 1995

3 bow thrusters at 1150 kW

SW&S, SW&S-a; SW&S-b; Thompson.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Fennica Rauma-Repola Oy			1993	First	DNV Finland		

Finnfellow					IA Super		rank: 3
137.37	24.54	17.35	—	2	19.3	—	PASS
126.40	24.69	8304	—	CPP	—	—	RORO
6.12		4995	10300	—	740 t.	—	
—			8240	—	—	Thrusters	

26 rail wagons, 55 trailers, 170 cars. Stern door/ramp, side door/ramp.

Bow thruster.

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Finnfellow Laivanisannistoyhtio Raiifellow Wartsilla Shipyards		Helsinki	1973	First	FR Finland		7214002
Finnmaid Laivanisannistoyhtio Raiifellow Wartsilla Shipyards	Hans Gutzeit, Capella	Helsinki	1972		FR Finland		

Finnfighter				IA Super		rank: 3
159.16	20.01	12.63		1	—	—	MPC
151.62	21.42		7280	CPP	—	—	
6.87			—	—	—	—	
9.15			—	—	—	—	

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Finnfighter Wartsilla Shipyards	Kaipola	Nassau		First	Bahamas		

Finnmerchant				IA Super		rank: 3
155.00	24.96	16.92		1	18.5	RORO
146.01	25.15		13200	CPP		
8.47						

SISTER SHIPS

SHIP NAME	FORMER NAMES		YR BUILT	First?	ICE RE	REG	LLOYD REG#
SHIP OWNER		HOME PORT			FLAG		
SHIPYARD		(MODERNIZATION)			(NOTES)		
(SPECIAL FEATURES)		(CHARTER RATE AND OP. COSTS)					
Finnmerchant				First	LR		
		Helsinki					
Rauma-Repola Oy							

Frontier Spirit				IA Super		rank: 3
111.50	17.00	11.90	MSDG	2	16.9	CONS	PASS
98.00	17.25	6752	4120	CPP	—	30	RV
—			—	—	—	—	
4.55		1226	4860	—	—	80	
—			—	—	—	—	
—							

second sister-ship is to be commissioned in late 1994

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Frontier Spirit Frontier Croises Ltd. Mitsubishi Heavy Industries		Nassau	1991		DNV Bahamas		

Gerakl			1 ships		L1		rank: 4
72.50	13.20	7.19	—	—	17.0	—	SALV
65.00	13.64	1655	—	—	—	—	TUG
—			—	—	—	—	
—			—	—	—	—	

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Gerakl Baltic Shipping Co.		St. Petersburg	1974	First	RR Russian Federation		7336587

Glomar Beaufort Sea I		
	89.91	30.48
95.24		11339
21.03		

IAA

rank: 3

DRIR

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Glomar Beaufort Sea I Nippon Kokan K.K.Tsu Shipyard		Houston			ABS		8402000

Henry Larsen	1 ships		4		rank: 1

100.03	19.51	
87.95	19.82	6166
7.20	8290	2478
—		

DIEL	2	15.5	—	IB
—	CPP	15000 n. mi.	—	
17760	4	—	—	
—	—	—	—	

Hangar for 1 helicopter.

Air bubbling system.

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Henry Larsen Transport Canada (Gov't of Canada) Versatile Pacific Shipyards Inc.		Ottawa	1988	First	CR Canada	LR	8409329

Highland Sentinel				IA		rank: 4
—	12.80	5.80	—	2	15.0	—	SUPP
60.39		919	—	CPP	—	—	
—			5176	4	—	—	
4.77			—	—	—	—	
—							

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Highland Sentinel Gulf Offshore N.S. Ltd. Teraoka SB Co.Ltd.		Panama	1974		ABS Panama		7421788

IgarkaLes			9 ships		L1		rank: 4
102.30	14.00	7.04	SSDG	1	13.6	CONV	TIMB
93.28		2730	1910	FPP	6630n.mi		
			2130	4		24	
5.92	5542	3629					

3250 t.

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
IgarkaLes			1962	First	RR Russian Federation		
IrtyshLes Baltic Shipping Co. Valmet Oy Helsingin Telakka		St. Petersburg	1963		RR Russian Federation		5424263
Istra Northern Shipping Company Valmet Oy Helsingin Telakka		Arkhangelsk	1964		RR Russian Federation		6405501
IzhmaLes Baltic Shipping Co. Valmet Oy Helsingin Telakka		St. Petersburg	1962		RR Russian Federation		5166158
IzhoraLes Baltic Shipping Co. Valmet Oy Helsingin Telakka		St. Petersburg	1963		RR Russian Federation		5166160
KamaLes Baltic Shipping Co. Hollming Oy-Rauma		St. Petersburg	1964		RR Russian Federation		6418364

Igor Grabar			6 ships		UL		rank: 3
97.32	16.00	7.70	SSDG	1	13.2	CONV	BULK
90.08	16.24	3184	2570	FPP	6000n.mi	—	TIMB
—			2830	4	—	23	
—			—	—	—	—	
6.36	6535	4054					

3580 t., cranes: 1@35 t. 1@20 t.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Igor Grabar Northern Shipping Company Hollming Oy-Rauma		Arkhangelsk	1973	First	RR Russian Federation		7231086
Ivan Shadr Northern Shipping Company		Arkhangelsk	1973		RR Russian Federation		
Konstantin Yuon Northern Shipping Company		Arkhangelsk	1973		RR Russian Federation		
Mikhail Cheremnykh Northern Shipping Company		Arkhangelsk	1973		RR Russian Federation		
Vera Mukhina Northern Shipping Company		Arkhangelsk	1973		RR Russian Federation		
Yekaterina Belashova Northern Shipping Company		Arkhangelsk	1973		RR Russian Federation		

Igor Ilyinski			8 ships		UL		rank: 3
132.70		8.80	SSDG	1	15.2	CONV	TIMB
122.00	19.86	7120	4335	CPP	7300n.mi	—	
—			5100	4	—	21	
6.88	11754	8256	—	—	—	—	
—							

6508 t., cont: 318@20', cranes: 4@20'

Low-friction, abrasion-resistant coating "Inerta 160"

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Abakan Karmi ltd. Ast. Reunidos del Nervion S.A.		Vladivostok	1990		RR Russian Federation		
Igor Ilyinski Far-Eastern Shipping Co. / Vladivostok Ast. Reunidos del Nervion S.A.		Vladivostok	1990	First	RR Russian Federation		8711253
Vysokogorsk Far-Eastern Shipping Co. / Vladivostok Ast. Reunidos del Nervion S.A.		Vladivostok	1991		RR Russian Federation		
Yelena Shatrova Far-Eastern Shipping Co. / Vladivostok Ast. Reunidos del Nervion S.A.		Vladivostok	1990		RR Russian Federation		

Ikaluk		
78.95		9.71
70.00	17.22	3256
8.11	5107	1900
7.53		

2 ships **4** **rank: 1**

MSDG	2	12.0	—	IB
—	CPP	—	—	SUPP
11000	4	—	19	TUG
150	—	20 m^3/day *	Thrusters	

* Fuel consumption rate in ice: 35-60 m^3/day.

Bow and stern thrusters, water jet lubrication system.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Ikaluk Canadian Marine Drilling Nippon Kokan K.K.Tsu Shipyard		Vancouver	1983		CR Canada	LR	8130693
Miscaroo Canadian Marine Drilling Nippon Kokan K.K.Tsu Shipyard			1983		CR Canada	LR	8127830

Ilyich			1	ships	L1		rank: 4
128.02	22.00	13.52	MSDG	2	22.0	—	FERR
115.80		12281	—	CPP	—	—	PASS
5.42			13240	—	681 t.	—	RORO
—			—	—	—	Thrusters	

Bow door, stern door.

Bow thruster.

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Ilyich Baltic Shipping Co. Wartsilla Shipyards	Stena Baltica	St. Petersburg	1973	First	RR Russian Federation		7224459

Ivan Papanin		
167.00	22.30	13.50
147.20	22.60	14184
—		
8.00	18090	7600
9.00	21000	10500
9.00	21000	10500

3 ships		ULA		rank: 2
SSDG	1	16.7	—	ASRV
28200	CPP	8000 n.mi.	—	RORO
29400	4	—	39	SUPP
—	Nozzles			
—	—	—	—	
1.1m.@1.5kn				

8900 t., 14400 m^3, cont: 329@20', cranes: 6@25 t. Can handle oversize (7x24 m.) & heavy (80 t.) units.

Room for 10 passangers and helicopter crew of 6

low-friction, abrasion-resistant coating. The ships in this series can serve as Antarctic Supply Vessels with range up to 14000 n. mi. (at a cost in deadweight).

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Ivan Papanin Murmansk Shipping Co. Kherson Shipyard		Murmansk	1990	First	RR Russian Federation		8837928
Snow Dragon			1990		Republic of China		
Yuvent Aqua Ltd. Shipping Kherson Shipyard			1992				

Jaguar					L1		rank: 4
92.79	15.63	7.70	SSDG	—	18.8	—	SALV
80.40		2781	—	—	—	—	TUG
5.90			—	—	—	Thrusters	
—			—	—	—	—	

Bow Thrusters.

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Bars Far Eastern Basin Administration Admiralty Ship Yard		Vladivostok	1977		RR Russian Federation		7729837

James Clark Ross					IA Super		rank: 3
99.04	18.85	9.80	DIEL	—	15.5	—	RV
90.00	18.89	5732	6250	—	—	—	SUPP
6.50	7400	2500	6650	—	1200 t.	—	
—			65	—	—	—	
		2917	1 m.@2 kn.				

A-boom: 1@30 t.

Bow & stern jet pumps

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
James Clark Ross		Port Stanley, Falkland Isl.	1991		LR Great Britain		8904496

Kapitan Belousov			3 ships		LL4		rank: 2
83.17	18.70	9.50	DIEL	4 1:1+0.5:0.5	16.5	CONS	IB
77.12	19.41	3710	7700	FPP	28days	22	
6.20	4500		8827	4 3.5	—	85	
			—	—	—	—	
7.00	5350		1m@2kn				

2 aft & 2 fore prop.

Tsoy (1992).

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Kapitan Belousov Azov Shipping Co. Wartsila Shipyards		Mariupol	1954	First	RR Ukraine		5181598
Kapitan Malakhov Wartsila Shipyards			1955		RR		
Kapitan Voronin Wartsila Shipyards			1955		RR		

Kapitan Chechkin	6 ships	LL4	rank: 2

	16.30	DIEL	3	1:1:1	14.0		RIB
76.50	16.60		CPP				
2.50	2240	3300	4				
		59					
3.30							

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Kapitan Bukaev Wartsilla Shipyards					RR Russian Federation		
Kapitan Chadaev Wartsilla Shipyards			1978		RR Russian Federation		
Kapitan Chechkin Wartsilla Shipyards			1977	First	RR Russian Federation		
Kapitan Krutov Wartsilla Shipyards			1978		RR Russian Federation		
Kapitan Plakhin Wartsilla Shipyards			1977		RR Russian Federation		
Kapitan Zarubin Wartsilla Shipyards			1978		RR Russian Federation		

Kapitan Gavrilov			10 ships		L1		rank: 4
203.06	25.40	15.90	SSDG	1	20.0	CONV	CONT
192.73	25.46	21584	15880	FPP	21000n.mi	—	
—			15660	4	—	27	
—			—	—	—	—	
9.82	25050	16030					

11810 t., cont: 1254@20'

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Kapitan Gavrilov Baltic Shipping Co. VEB Warnemuende		St. Peterburg	1982	First	RR Russian Federation		8201624
Kapitan Kanevskiy Baltic Shipping Co.		St. Petersburg	1982		RR Russian Federation		
Kapitan Kozlovskiy Baltic Shipping Co.		St. Petersburg	1982		RR Russian Federation		
Nikolay Tikhonov Baltic Shipping Co.		St. Petersburg	1983		RR Russian Federation		
Professor Tovstykh Baltic Shipping Co.		St. Petersburg	1985		RR Russian Federation		
Tikhon Kiselyov Baltic Shipping Co.		St. Petersburg	1984		RR Russian Federation		

Kapitan Goncharov			3 ships		UL		rank: 3
131.60	19.30	8.80	SSDG	1	15.0	CONV	MPC
122.00		6395	—	FPP	6500n.mi	—	
7.00	11170	7700	4690	4	—	30	
—		7000	—	—	—	—	

6130 t., cont: 272@20', grain: 9660 m^3, cranes: 2@12.5 t.

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Kapitan Chmutov Baltic Shipping Co. Malta SB. Co. Ltd		St. Petersurg	1991		RR Russian Federation		
Kapitan Goncharov Baltic Shipping Co. Malta SB. Co. Ltd		St. Peterburg	1989	First	RR Russian Federation		8502042
Kapitan Primak Baltic Shipping Co. Malta SB. Co. Ltd		St. Petersburg	1990		RR Russian Federation		

Kapitan Gotskii	6 ships	ULA	rank: 2

133.00	18.50	11.60	DIEL	1	15.0		MPC
118.40	18.80	7684	4760	FPP	8000n.mi.	29	
7.60	11290	6280	5300	4	—	55	
—			—	—	—	—	
8.90	13840	8723	0.7 m. @ 2kn				

5000 t., cranes: 2@60 t. 2@10 t.
6@5 t.

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Kapitan Gotskii Far-Eastern Shipping Co. / Vladivostok Leninskogo Komsomola	Amguema	Vladivostok	1965	First	RR Russian Federation		6822694
Kapitan Kondratjev Far-Eastern Shipping Co. / Vladivostok Leninskogo Komsomola		Vladivostok	1972		RR Russian Federation		
Kapitan Myshevskiy Far-Eastern Shipping Co. / Vladivostok Leninskogo Komsomola		Vladivostok	1970		RR Russian Federation		
Navarin Murmansk Shipping Co. Leninskogo Komsomola		Murmansk	1967		RR Russian Federation		
Pavel Ponomaryov Murmansk Shipping Co. Leninskogo Komsomola		Murmansk	1971		RR Russian Federation		
Vasiliy Fedoseyev Far-Eastern Shipping Co. / Vladivostok Leninskogo Komsomola		Vladivostok	1969		RR Russian Federation		

Kapitan Lus			1A		rank: 4

98.20		7.80
89.40	17.60	
—		
6.70		4670

—	1	12.5	CONV	BULK
	—	5000 n. mi.	40	CONT
3360	—	—	22	TIMB
—	—	—	—	
—	—	—		

5654 m^3 in 3 holds, double-hull, 4125 t., cont: 241, cranes: 2@8 t.@22m.

Vinogradov.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Kapitan Lus Northern Shipping Company Vyborg Shipyard		Arkhangelsk	1993		RR Russian Federation		

Kapitan M. Izmailov	3 ships	LL4	rank: 2

56.50	15.60	6.00	DIEL	2	14.0		RIB
52.20	16.00		2500	FPP	15days	25	
4.20	2050		3940	4	—	24	
—			—	—	—	—	
			0.6 m. @3 kn.				

Tsoy (1992).

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Kapitan A. Radjabov Wartsilla Shipyards		Baku	1976		RR Azerbaidjan		
Kapitan Kosolapov Wartsilla Shipyards			1976		RR Russian Federation		
Kapitan M. Izmailov Baltic Shipping Co. Wartsilla Shipyards		St. Petersburg	1976	First	RR Russian Federation		

Kapitan Panfilov		
146.10		12.89
134.40	20.59	10145
—		
—		
9.42	20165	14632

13742 t.

11 ships **L1** **rank: 4**

SSDG	1	14.0	CONV	BULK
4490	FPP	6000n.mi		
4930	4	—	26	
—	—	—	—	

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Kapitan Panfilov			1975	First	RR		

Kapitan Sakharov	5 ships	UL	rank: 3

130.00	17.00	8.50
119.00	17.30	4827
—		
—		
6.92	17150	5780

SSDG	1	15.0	CONV	CONT
4440	FPP	6500n.mi	—	
4930	4	—	31	
—	—	—	—	

4410 t., cont: 320@20'

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Kapitan Gnezdilov Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1980		RR Russian Federation		
Kapitan Krems Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1980		RR Russian Federation		
Kapitan Sakharov Northern Shipping Company Vyborg Shipyard		Arkhangelsk	1979	First	RR Russian Federation		7831757
Kapitan Sergiyevskiy Far-Eastern Shipping Co. / Vladivostok		Vladivistok	1981		RR Russian Federation		
Kapitan Zheltovskiy Northern Shipping Company		Archangelsk	1980		RR Russian Federation		

Kapitan Sorokin			4 ships			LL3		rank: 1
141.40		12.30	DIEL	3	1:1:1	18.5		IB
130.20	30.50	10609	16200	FPP		28days	12	
			18100	4		—	83	
8.50	17270		181	—		—	—	
—			2.25 m.					

Petrakov; Simonov; Tsoy (1993); Tsoy (1992); Tsoy (1990); SW&S (1992).

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Kapitan Dranitsyn Murmansk Shipping Co.		Murmansk	1980		RF Russian Federation		
Kapitan Khlebnikov Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1981		RR Russian Federation		
Kapitan Nikolayev Murmansk Shipping Co.		Murmansk 1991, Kvaerner Masa Yards modified as follows: Sledge-shaped bow installed. Dimensions changed: LBP=132.00 m., Displ=17270 t., Speed=18 kn., ice capability=1.9 m.	1978		RR Russian Federation		
Kapitan Sorokin Murmansk Shipping Co. Oy Wartsila Ab		Murmansk Moderniz. made by "Thyssen Nordseewerk". Original bow replaced by Tyssen-WAAS bow shape. Dimensions changed as follows: LOA=141.44 m.; LPB=132.39 m., Breadth=30.50 m., Displ.=17150 t., Speed=18.5 kn., Ice capability=1.8 m.	1977	First	RR Russian Federation		7413488

Kapitan Yevdokimov	8 ships	LL4	rank: 2

71.20	16.60	4.60	DIEL	4	13.5		RIB
76.50			3794	FPP	—	25	
—			4809	4	—	—	
2.50	2150		—	—	—	—	
—							

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES / HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Kapitan Babichev Kvaerner Masa-Yards		1983		RR Russian Federation		
Kapitan Borodkin Kvaerner Masa-Yards		1983		RR Russian Federation		
Kapitan Chudinov Kvaerner Masa-Yards		1983		RR Russian Federation		
Kapitan Demidov Kvaerner Masa-Yards		1984		RR Russian Federation		
Kapitan Mecaik Kvaerner Masa-Yards		1984		RR Russian Federation		
Kapitan Moshkin Kvaerner Masa-Yards		1986		RR Russian Federation		
Kapitan Yevdokimov Kvaerner Masa-Yards		1983	First	RR		
Kapitan Zavenyagin Kvaerner Masa-Yards		1984		RR Russian Federation		

Katmai Bay **rank: 3**

—	11.28	3.66
42.68		500
—		
—		
—		

—	—	—	—	IB
—	—	—	—	TUG
—	—	—	—	
—	—	—	—	

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Katmai Bay US Coast Guard Tacoma Boatbuilding Company Inc.		Washington	1978		ABS U.S.A.		

Kiisla | **IA** | **rank: 4**

17.60		MSDG	1	14.0		TANK
105.20			CPP			
6.60	5750	3700	4			

pumps: 12

air bubbling system installed. Double-skin hull.

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Kiisla Neste Oy Valmet Oy Helsingin Telakka		Naantali/Nadendal	1973	First	FR Finland		7347500

Komandor			4 ships		L1		rank: 4
88.30	13.60	6.60	—	1	19.2	—	PATR
82.20	13.60	2800	—	CPP	7000 n. mi.	—	SALV
—			56704	—	—	42	
4.70		534	—	—	—	—	
—			—	—	—	—	

Hangar for 1 helicopter Ka32C

Active side rudders make it possible for helicopter to land and take off in 8.5 m. waves (sea state 7 on Beaufort Scale).

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Komandor Danyard			1989		RR Russian Federation		

Kosmonavt Pavel Beliayev | **L1** | **rank: 4**

123.15	16.69	10.80
113.00	16.74	5473
		2460
6.71		

		14.8	CONV	RV
3825	4			

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Kosmonavt Pavel Beliayev Baltic Shipping Co. Zhdanov Shipyards	Vytegrales-74	St. Peterburg	1969	First	Russian Federation		5409732
Kosmonavt V. Patsayev Baltic Shipping Co.		St. Petersburg	1968		RR Russian Federation		
Kosmonavt V. Volkov Baltic Shipping Co.		St. Petersburg	1964		RR Russian Federation		

KotlasLes			15 ships		L1		rank: 4
102.10	14.00	6.85	SSDG	1	13.6	CONV	TIMB
93.00		2924	1910	FPP	8500n.mi	—	
—			2130	4	—	24	
—			—	—	—	—	
5.70	5335	3480					

3082 t.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
KotlasLes			1962	First	Russian Federation		

Krymsk			**21 ships**		**L1**		**rank: 4**
104.50		7.10	SSDG	1	13.5	CONV	TIMB
94.50	14.36	3019	1910	FPP	6000n.mi	—	
			2130	4	—	24	
—			—	—	—	—	
6.05	6000	3860					

3440 t.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Anton Buyukly Sakhalin Shipping Co.		Kholmsk	1969		RR Russian Federation		
Boris Nikolaychuk Sakhalin Shipping Co.		Kholmsk	1969		RR Russian Federation		
Karaga Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1970		RR Russian Federation		
Katangli Sakhalin Shipping Co.		Kholmsk	1968		RR Russian Federation		
Kavalerovo Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1970		RR Russian Federation		
Kirensk VietSovLikhter			1968		RR Russian Federation		
Krasnopolye Sakhalin Shipping Co.		Kholmsk	1968		RR Russian Federation		
Krasnoturjinsk Sakhalin Shipping Co.		Kholmsk	1968		RR Russian Federation		
Krymsk Azov Shipping Co. Santierul Naval Galatz		Marinpol	1964	First	RR Russian Federation		6728874
Kulunda Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1970		RR Russian Federation		
Kuznetsk Sakhalin Shipping Co.		Kholmsk	1969		RR Russian Federation		

Stepan Savushkin Sakhalin Shipping Co.	Kholmsk	1969	RR Russian Federation
Tymovsk Sakhalin Shipping Co.	Kholmsk	1970	RR Russian Federation
Yevgeniy Chaplanov Sakhalin Shipping Co.	Kholmsk	1970	RR Russian Federation

Krystall			1	ships	L1		rank: 4
152.70	22.00	13.60	SSDG	1	17.4		REFR
142.00		12380	—	FPP	—	—	
—			7600	4	—	35	
—			—	—	—	—	
7.96	16600	9400					

8380 t.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Krystall		Major modernization in 1993 included: replacement of the original steam turbo-electric plant with a diesel-electric system. Original 6.7 MW propulsion motors were retained. Bow was also replaced.	1985	First	RR		

Kulluk		
81.00	81.00	18.50
—		29147
—		
12.53		
—		
—		

IAA

rank: 3

—	—	—	—	DRIR
—	—	—	—	
—	—	—	—	
—	—	—	—	

Non-self-propelled barge drilling unit.

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Kulluk Mitsui SB & Engineering Co.,Ltd.		Vancouver,B.C.			ABS		

LadogaLes	6 ships		L1		rank: 4
102.34 13.85 6.89	SSDG	—	13.8	CONV	MPC
93.02 14.03 2866	—	—	7600	—	TIMB
5.91 5356 3455	2133	4	—	24	
— 3796	—	—	—	—	

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Indiga Baltic Shipping Co.		St. Petersburg	1965		RR Russian Federation		
Kolguyev Sakhalin Shipping Co.		Kholmsk	1965		RR Russian Federation		
KostromaLes Baltic Shipping Co.		St. Petersburg	1964		RR Russian Federation		
Ladogales Baltic Shipping Co. Valmet Oy Helsingin Telakka		St. Petersburg	1964	First	RR Russian Federation		6412097
NevaLes Baltic Shipping Co.		St. Petersburg	1965		RR Russian Federation		
Saldus Baltic Shipping Co.		St. Petersburg	1965		RR Russian Federation		

Lena					ULA		rank: 2
130.20	19.00	10.62	DIEL	1	14.0	CONV	MPC
117.30	19.25	5753	4235	FPP	1350 n. mi.	—	
8.27	12600	7439	6200	4	—	—	
			—	—	—	—	
8.70		7986	0.73m @ 2kn				

5730 t. cont: 461@20', cranes: 2@(60-150 t.)

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Lena		Hamburg	1957	First	GL Russian Federation		8902321

Lenin			1 ships			LL2	CONS	rank: 1
134.00	26.80	16.10	NPTE	3	1:2:1	19.7	CONS	
124.00	27.60		28800	FPP		Unlimited	30	
10.40	19240		32360	4				
			1.65 m. @2 kn.					

Ship decommissioned.

Tsoy (1992); Tsoy (1993); Tsoy (1990)

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Lenin Murmansk Shipping Co. Admiralty Ship Yard		Murmansk	1959	First	RR Russian Federation		

Libby G		
—	18.80	10.20
117.00		5267
—		
7.47	11565	7766
—		
—		

		A		rank: 3
—	—	15.0	—	CHEM
—	—	—	—	TANK
4530	4			
—	—	—	—	
—	—	—	—	

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Libby G Libby G. Nippon Kokan K.K.Tsu Shipyard		Monrovia	1980		ABS Liberia		8010845

Louis S. St. Laurent	1 ships		4		rank: 1

112.00	24.38	13.10
101.86		10908
9.40	13300	
8.99		
10.30		4714

DIEL	3	1:1:1	17.8	—	CGIB
17900	FPP		16600 n.mi.	—	
—	4		—	—	
—	—		—	—	
2 m.@4 kn.					

Dick; Tsoy (1993); MER 01/94; Wind.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES / HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Louis S. St. Laurent Transport Canada (Gov't of Canada) Canadian Vickers Shipyard Ltd.	 Ottawa	1969	First	CR Canada		6705937

Lunni			4 ships			IA Super		rank: 3
164.50	21.50	12.00	MSDG	1		14.5	_	TANK
154.00	22.26	11290	_	CPP		_	_	
9.50		16000	11500	4	5.5	_	_	
_			_	_		_	_	
			1.0 m.@2 kn.					

Pumps: 8

A former sister tanker from this series, the "Uikku", was converted in 1993 to accomodate azimuthing propulsion drive "Azipod". See under series name "Uikku".

Air bubbling system installed.

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Lunni Neste Oy Verft Nobizkrug Gmbh.		Naantali/Nadendal	1976	First	DNV Finland		7421942

Marinor IA **rank: 4**

112.20	18.00	9.50	SSDG	1	14.5			CHEM
104.66		4950	4050	CPP			90	TANK
7.50		7500			4.5	570 t.	22	
9.50								

8500 m^3, pumps: 9, all 12 tanks are constructed of Avesta type-220S stainless steel.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Marinor		Harlingen	1992		LR		9043794

Mariya Yermolova L1 **rank: 4**

100.00	16.21	7.00
90.00	16.24	3941
4.65		1465
—		

SSDG	—	17.0	CONV	FERR
—	—	—	—	PASS
38821	4	—	—	
—	—	—	—	

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Alla Tarasova Murmansk Shipping Co.		Murmansk	1975		RR Russian Federation		
Antonina Nezhdanova Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1978		RR Russian Federation		
Klavdia Yelanskaya Murmansk Shipping Co.		Murmansk	1977		RR Russian Federation		7422922
Lyubov Orlova Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1976		RR Russian Federation		7391434
Mariya Savina Far-Eastern Shipping Co. / Vladivostok Titovo Brodogradiliste		Vladivostok	1975		RR Russian Federation		7391410
Mariya Yermolova Murmansk Shipping Co.		Murmansk	1974	First	Russian Federation		7367524
Olga Sadovskaya Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1977		RR Russian Federation		

Mary Christina		
87.90		7.70
84.90	12.30	2561
5.30	4536	

IA **rank: 4**

MSDG	1	12.5	CONV	BULK
			45	CONT
1850			8	
			Thrusters	

5548 m^3.

Bow thrusters @200 kW.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES / HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Mary Christina						

Mekhanik Yartsev			10 ships			L1		rank: 4
85.20	14.20	6.00	SSDG	1		12.6	CONV	BULK
79.40	14.50	2489		CPP		5000 n. mi.		TIMB
4.70		2291	2074	4	2.9	170 t.	20	
							Thrusters	
5.05		2636						

2 cargo holds 1184 m^3 & 1727 m^3, cranes @5 t. @20 m.

Bow thrusters @185 kW.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Mekhanik Brilin Northern Shipping Company Osterreichische Schifswerten A.G. Linz		Arkhangelsk	1991		RR Russian Federation		
Mekhanik Fomin Northern Shipping Company		Arkhangelsk	1991		RR Russian Federation		
Mekhanik Kotsov Northern Shipping Company		Arkhangelsk	1991		RR Russian Federation		
Mekhanik Makarjin Northern Shipping Company		Arkhangelsk	1991		RR Russian Federation		
Mekhanik Pustoshnyi Northern Shipping Company		Arkhangelsk	1992		RR Russian Federation		
Mekhanik Pyatlin Northern Shipping Company		Arkhangelsk	1992		RR Russian Federation		
Mekhanik Yartsev Northern Shipping Company Osterreichische Schifswerten A.G. Linz		Arkhangelsk	1990	First	RR Russian Federation		8904367

Mikhail Kalinin | **L1** | **rank: 4**

122.15	15.96	7.62
109.99	16.03	5243
—		
—		
5.85		1358

—	1	18.0	CONV	PASS
—	FPP	—	—	
6106	4	—	—	
—	—	—	—	

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Baykal Baikal Shipping Co.			1963		RR		
Estonia Baltic Shipping Co.		St. Petersburg	1960		RR Russian Federation		
Mikhail Kalinin Baltic Shipping Co. VEB Mathias-Thesen-Werft		St. Peterburg	1958	First	RR Russian Federation		5234917
Nikolayevsk Murmansk Shipping Co.		Murmansk	1962		RR Russian Federation		
Petropavlovsk Kamchatka Shipping Co.		Petropavlovsk-Kamchatskii	1960		RR Russian Federation		

Mikhail Somov	1 ships	UL	rank: 3

133.13		
—	18.85	7696
—		
11.61		8220
—		
9.05		

DIEL	—	—	—	ASRV
—	—	—	—	RV
—	—	—	—	
—	—	—	—	

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Mikhail Somov Arctic and Antarctic Research Institute Wartsilla Shipyards			1975	First			

Mikhail Strekalovski			14 ships		UL		rank: 3
162.10	22.86	13.50	SSDG	1	15.2	CONV	BULK
154.88	22.92	13950	7430	FPP	6000 n.mi.		
			8240	4	—	26	
—			—	—	—	—	
9.88	27340	19252					

18104 t., cont: 442@20', cranes: 6@12.5 t.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Anatoliy Lyapidevskiy Murmansk Shipping Co.		Murmansk	1984		RR Russian Federation		
Ivan Makarjin Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1981		RR Russian Federation		
Kapitan Bochek Murmansk Shipping Co.		Murmansk	1982		RR Russian Federation		
Kapitan Chukhchin Murmansk Shipping Co.		Murmansk	1981		RR Russian Federation		
Kapitan Kudlay Murmansk Shipping Co.		Murmansk	1983		RR Russian Federation		
Kapitan Nazarjev Murmansk Shipping Co.		Murmansk	1984		RR Russian Federation		
Kapitan Sviridov Murmansk Shipping Co.		Murmansk	1982		RR Russian Federation		
Kapitan Tsirul' Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1981		RR Russian Federation		
Kapitan Vakula Murmansk Shipping Co.		Murmansk	1983		RR Russian Federation		
Kapitan Vodenko Murmansk Shipping Co.		Murmansk	1982		RR Russian Federation		
Mikhail Strekalovski Murmansk Shipping Co. VEB Warnowwerft Warnemuende		Murmansk	1981	First	RR Russian Federation		8131881

Pavel Vavilov Murmansk Shipping Co.	Murmansk	1981	RR Russian Federation
Tim Bak Murmansk Shipping Co.	Murmansk	1983	RR Russian Federation
Victor Tkachev Murmansk Shipping Co.	Murmansk	1982	RR Russian Federation

Mirnyy	46 ships	L1	rank: 4

102.27	14.00	6.89	—	1	13.5	CONV	MPC
93.02	14.03	2920	—	FPP	—	—	TIMB
6.20		3930	2133	4	—	—	
—			—	—	—	—	

Dick; MER 01/94.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES / HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Blagoveshensk Sakhalin Shipping Co.	Kholmsk	1969		RR Russian Federation		
Chazhma Kamchatka Shipping Co.	Petropavlovsk-Kamchatskii	1968		RR Russian Federation		
Guse-Khrustalnyi Baltic Shipping Co.	St. Petersburg	1970		RR Russian Federation		
Iljinsk DVVIMU		1967		RR Russian Federation		
Jose Diaz Baltic Shipping Co.	St. Petersburg	1967		RR Russian Federation		
Kaliningrad Baltic Shipping Co.	St. Petersburg	1969		RR Russian Federation		
Kamchadal Kamchatka Shipping Co.	Petropavlovsk-Kamchatskii	1969		RR Russian Federation		
Kamchatskiy Komsomolets Kamchatka Shipping Co.	Petropavlovsk-Kamchatskii	1968		RR Russian Federation		
Kapitan Gastello Baltic Shipping Co.	St. Petersburg	1967		RR Russian Federation		
Kharlov Baltic Shipping Co.	St. Petersburg	1968		RR Russian Federation		
Kikhchik Kamchatka Shipping Co.	Petropavlovsk-Kamchatskii	1971		RR Russian Federation		

Kimry Baltic Shipping Co.	St. Petersburg	1969		RR Russian Federation	
Kingisepp Baltic Shipping Co.	St. Petersburg	1969		RR Russian Federation	
Koporje Far-Eastern Shipping Co. / Vladivostok	Vladivostok	1968		RR Russian Federation	
Kozyrevsk Kamchatka Shipping Co.	Petropavlovsk-Kamchatskii	1971		RR Russian Federation	
Krasnoborsk Baltic Shipping Co.	St. Petersburg	1970		RR Russian Federation	
Krasnoyarsk Kamchatka Shipping Co.	Petropavlovsk-Kamchatskii	1968		RR Russian Federation	
Kuzminki Baltic Shipping Co.	St. Petersburg	1970		RR Russian Federation	
Ligovo Baltic Shipping Co.	St. Petersburg	1967		RR Russian Federation	
Lomonosovo Baltic Shipping Co.	St. Petersburg	1968		RR Russian Federation	
Mirnyi Kamchatka Shipping Co. USSA	Petropavlovsk-Kamchatskii	1967	First	RR Russian Federation	6617441
Palana Kamchatka Shipping Co.	Petropavlovsk-Kamchatskii	1967		RR Russian Federation	
Pervouralsk Sakhalin Shipping Co.	Kholmsk	1966		RR Russian Federation	
Shushenskoye Kamchatka Shipping Co.	Petropavlovsk-Kamchatskii	1970		RR Russian Federation	
Sofja Perovskaya Baltic Shipping Co.	St. Petersburg	1967		RR Russian Federation	
Tampere Sakhalin Shipping Co.	Kholmsk	1967		RR Russian Federation	

Tobol Sakhalin Shipping Co.	Kholmsk	1969	RR Russian Federation
Turku Baltic Shipping Co.	St. Petersburg	1967	RR Russian Federation
Vaga Kamchatka Shipping Co.	Petropavlovsk-Kamchatskii	1967	RR Russian Federation
Velikiy Ustyug Baltic Shipping Co.	St. Petersburg	1969	RR Russian Federation
Yantarnyi Baltic Shipping Co.	St. Petersburg	1968	RR Russian Federation

Molikpaq			IAA		rank: 3
111.00	29.00	—	—	—	DRIR
111.00	42317	—	—	—	
21.30		—	—	—	
—		—	—	—	

Caisson driling unit.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Molikpaq Ishikawajima-Harima Heavy Ind.Co.Ltd.		Vancouver, B.C.			ABS		8402266

Moskva	5 ships		LL3		rank: 1
122.10 23.50 14.00	DIEL	3 1:2:1	18.3	CONS	IB
112.40 24.50 9427	16200	FPP	38 days	26	
9.50 13290	19120	4	—	85	
	226	—	—	—	
10.50 15400 6147	1.4 m.@2 kn.				

cranes: 2@10 t. 2@1.5 t.

Dick; Tsoy (1993); Tsoy (1992); Tsoy (1990).

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Kiev Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1965		RR Russian Federation		
Leningrad Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1961		RR Russian Federation		
Moskva Far-Eastern Shipping Co. / Vladivostok Wartsilla Shipyards		Vladivostok	1960	First	RR Russian Federation		
Murmansk Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1968		RR Russian Federation		
Vladivostok Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1969		RR Russian Federation		

Mudyug			3 ships			LL3		rank: 1
88.60	20.00	10.50	MSDG	2		16.1	CONS	IB
78.50	21.20	5342	7000	CPP		30 days	26	TUG
			9560	4	4.0		32	
6.00	5560							
	7250	1909	0.98 m.@2 kn.					

Orlano-Erenya; Simonov; Tsoy (1993); Tsoy (1992); Tsoy (1990); Zakharov.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Dikson			1983		RR Russian Federation		
Magadan Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1982		RR Russian Federation		
Mudyug Wartsilla Shipyards		This ship was converted to Thyssen-WAAS bow shape in 1989. The new dimensions are: LOA=111.4 m.; Lwl=89.8 m.; Bmax=22.2 m.; Displ. @wl=6880 t.; Icebreaking capability in level ice is 1.5 m.@2 kn.	1982	First	RR Russian Federation		

Nathaniel B. Palmer			A2			rank: 2

94.05	18.29	9.45
85.27		6174
6.63	6384	
—		
		2500

MSDG	2		15.0	SLED	IB
9500	CPP		75 days	30	RV
9900	4	4.0	1639 t.	26	
—	—		—	—	

Accomodates 27 scientists.

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Nathaniel B. Palmer North American SB,Inc.		Galliano	1992		ABS		9200734

Nikolay Novikov			25 ships		L1		rank: 4
150.08		11.60	SSDG	1	15.5	CONV	BULK
139.86	20.98	10185	6360	FPP	12000 n.mi.		TIMB
			7060	4		26	
8.69	19730	13955					

11910 t.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Botsman Moshkov Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1976		RR Russian Federation		
Fyodor Varaskin Northern Shipping Company		Arkhangelsk	1977		RR Russian Federation		
Ivan Syrykh Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1973		RR Russian Federation		
Kapitan Bakanov Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1974		RR Russian Federation		
Kapitan Burmakin Northern Shipping Company		Arkhangelsk	1976		RR Russian Federation		
Kapitan Dublitskiy Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1975		RR Russian Federation		
Kapitan Glazachev Northern Shipping Company		Arkhangelsk	1976		RR Russian Federation		
Kapitan Kiriy Sakhalin Shipping Co.		Kholmsk	1974		RR Russian Federation		
Kapitan Lyubchenko Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1976		RR Russian Federation		
Kapitan Milovzorov Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1975		RR Russian Federation		
Kapitan Mochalov Northern Shipping Company		Arkhangelsk	1974		RR Russian Federation		

Kapitan Samoylenko Far-Eastern Shipping Co. / Vladivostok	Vladivostok	1975		RR Russian Federation	
Kapitan Shevchenko Far-Eastern Shipping Co. / Vladivostok	Vladivostok	1976		RR Russian Federation	
Kapitan Vasilevskiy Far-Eastern Shipping Co. / Vladivostok	Vladivostok	1976		RR Russian Federation	
Kapitan Zamyatin Northern Shipping Company	Arkhangelsk	1975		RR Russian Federation	
Konstantin Petrovskiy Far-Eastern Shipping Co. / Vladivostok	Vladivostok	1974		RR Russian Federation	
Mekhanik Gordienko Far-Eastern Shipping Co. / Vladivostok	Vladivostok	1973		RR Russian Federation	
Nikolay Novikov Northern Shipping Company Stocznia Gdanska im. Lenina	Arkhangelsk	1973	First	RR Russian Federation	7301104
Pyotr Smidovich Northern Shipping Company	Arkhangelsk	1975		RR Russian Federation	
Pyotr Strelkov Northern Shipping Company	Arkhangelsk	1977		RR Russian Federation	
Vasilliy Musinskiy Northern Shipping Company	Arkhangelsk	1975		RR Russian Federation	
Vladimir Mordvinov Far-Eastern Shipping Co. / Vladivostok	Vladivostok	1973		RR Russian Federation	
Vladimir Timofeyev Northern Shipping Company	Arkhangelsk	1973		RR Russian Federation	
Vlas Nichkov Northern Shipping Company Stocznia Gdanska im. Lenina	Arkhangelsk	1974	First	RR Russian Federation	7362419
Yuriy Savinov Sakhalin Shipping Co.	Kholmsk	1976		RR Russian Federation	

Nikopol		
83.42		5.31
74.00	12.02	1630
—		
—		
4.65	2920	1660

6 ships		L1		rank: 4
SSDG	1	13.2	CONV	TANK
—	FPP	2500 n.mi.	—	
1470	4	—	25	
—	—	—	—	

1540 t.

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Nikopol Primorsk Shipping Co. Kerch Shipyard	Baskunchak	Nakhodka	1964	First	RR Russian Federation		7029639

Norilsk (a.k.a. SA-15)			14 ships			ULA		rank: 2
174.00	24.00	15.20	MSDG	1		17.0	CONS	BULK
164.00	24.50	16500	14200	CPP		12000 n.mi.	30	CONT
8.50	24100	12900	15400	4	5.6	—	39	MPC
9.00	25900	14700	160	—		—	—	
10.50	31200	20000	1.0m.@2 kn.					

8555 t. @wl; 10345 t. @arc; 15700 t. @max.

Cargo helicopter "ka-32C", 5 ton capacity;
2 ACVs, 20 ton capacity.

Hangar and landing pad.

Air-bubbling and water jet system.

Low-friction, abrasion-resistant coating.

Narby; Simonov; Tsoy (1993); Tsoy (1992); Tsoy (1990).

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Amderma Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1983		RR Russian Federation		
Anadyr Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1984		RR Russian Federation		
Arkhanghelsk Murmansk Shipping Co.		Murmansk	1983		RR Russian Federation		
Bratsk Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1983		RR Russian Federation		
Igarka Far-Eastern Shipping Co. / Vladivostok Oy Wartsila Ab		Vladivostok	1983	First	RR Russian Federation		8013027
Kandalaksha Murmansk Shipping Co.		Murmansk	1984		RR Russian Federation		
Kemerovo Sakhalin Shipping Co.		Kholmsk	1983		RR Russian Federation		
Kola Murmansk Shipping Co.		Murmansk	1983		RR Russian Federation		
Monchegorsk Murmansk Shipping Co.		Murmansk	1983		RR Russian Federation		
Nikel Murmansk Shipping Co.		Murmansk	1984		RR Russian Federation		

Nizhneyarsk Far-Eastern Shipping Co. / Vladivostok	Vladivostok	1983		RR Russian Federation
Norilsk Murmansk Shipping Co. Wartsilla Shipyards	Murmansk	1982	First	RR Russian Federation
Okha Sakhalin Shipping Co.	Kholmsk	1983		RR Russian Federation
Tiksi Murmansk Shipping Co.	Murmansk	1983		RR Russian Federation

Norse Mersey		
178.70	23.68	17.35
166.47	24.54	20914
5.72		14800
—		

IA Super **rank: 3**

	2	18.0	
—	CPP	—	—
8200	—	—	—
—	—	—	—
—	—	—	—

SISTER SHIPS

SHIP NAME	FORMER NAMES		YR BUILT	First?	ICE RE	REG	LLOYD REG#
SHIP OWNER		HOME PORT			FLAG		
SHIPYARD		(MODERNIZATION)			(NOTES)		
(SPECIAL FEATURES)		(CHARTER RATE AND OP. COSTS)					

Novaya Ladoga (Pr. 596) | **L1** | **rank: 4**

121.95	16.69	8.31
113.01	16.74	4676
5.99		6460
—		

MSDG	—	15.7	—	MPC
—	—	—	—	
3825	—	—	—	
—	—	—	—	

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Bakaritsa Northern Shipping Company		Arkhangelsk	1968		RR Russian Federation		
Isakogorka Northern Shipping Company Zhdanov Shipyards		Arkhangelsk	1968		RR Russian Federation		6909571
Komsomolets Sakhalina Sakhalin Shipping Co. Vyborg Shipyard		Kholmsk	1971		RR Russian Federation		7121449
Kuloy Northern Shipping Company Vyborg Shipyard		Archangelsk	1967		RR Russian Federation		6919162
Maymaksa Northern Shipping Company Vyborg Shipyard		Arkhangelsk	1968		RR Russian Federation		6912176
Novaya Ladoga Baltic Shipping Co. Zhdanov Shipyards		St. Petersburg	1967	First	RR Russian Federation		6906634
Oka Northern Shipping Company		Arkhangelsk	1967		RR Russian Federation		6909583
Vasya Alekseyev Baltic Shipping Co. Zhdanov Shipyards		St. Petersburg	1967		RR Russian Federation		6906672
Vostok-2 Northern Shipping Company Zhdanov Shipyards		Arkhangelsk	1965		RR Russian Federation		6914617
Zolotitsa Northern Shipping Company Zhdanov Shipyards		Arkhangelsk	1967		RR Russian Federation		6909595

Novy Donbass			2 ships		L1		rank: 4
100.60	13.90	8.10	SSDG	1	13.2	CONV	MPC
90.00		2354	1656	FPP	5000 n.mi.	—	
			1840	4	—	24	
—			—	—	—	—	
5.50	5125	2990					

2651 t.

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Novy Donbass Ukraine D.S. Santierul Naval Galatz		Izmail	1963	First	RR Ukraine		6419617

Oden			1 ships		Polar-20		rank: 1
107.80	25.00	12.00		2	17.0		IB
93.20	31.08	9438	7720	CPP	30000 n.mi.		
7.00	13000		18000	4			
8.50		4906	1.8m.@3 kn.				

Helicopter deck.

12000 n.mi. range in 0.9 m. thick ice

Dick.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Oden Svensk Isbrytarkonsortium KB Gotaverken Arendal AB		Stokholm	1989	First	DNV Sweden		8700876

Otso	2 ships					rank: 1

99.00	23.50	11.30	DIEL	2	18.5	CONS	IB
90.00	24.20	6000	15000	CPP	—	30	
8.00	8500	4900	21840	4	—	28	
			—	Nozzles	—	—	
8.50	13000	2000	1.4 m.				

Air bubbling system installed.
Stainless steel belt plating in ice contact zone.

Dick.

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Kontio			1987		FR Finland		
Otso Finnish Board of Navigation Wartsilla Shipyards		Helsinki	1986	First	FR Finland	FR	8405880

Otto Schmidt	1 ships	LL4	rank: 2

112.00	18.62	8.31
73.00	19.80	2828
—	3700	
—		
6.62		1095

DIEL	2	15.0	CONV	IB
3975	FPP	—	29	RV
—	4	—	—	
—	—	—	—	

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Otto Schmidt Murmansk Hydrometeorology Admiralty Ship Yard		Murmansk	1979	First	RR Russian Federation		7828671

Pandora II					IAA		rank: 3
55.76	13.72	5.03	DIEL	2	20.0	—	MSH
53.32	13.75	1378	—	CPP	—	—	SUPP
4.43			3824	4	—	—	
—			—	—	—	—	

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Pandora II Northern Shipping Company Bel-Aire Shipyard,Ltd.		Halifax	1974		ABS Canada		

Partizansk			11 ships		UL		rank: 3
97.35	14.20	6.50	MSDG	1	13.5	CONV	TANK
90.10	14.23	2968	—	CPP	2500n.mi	—	
—		2500	2870	4	—	23	
—			—	—	—	—	
4.90	4855	2833					

2350 t., 3230 m^3

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Angarsk Primorsk Shipping Co.		Nakhodka	1990		RR Russian Federation		
Arsenyev Primorsk Shipping Co.		Nakhodka	1989		RR Russian Federation		
Belogorsk Primorsk Shipping Co.		Nakhodka	1988		RR Russian Federation		
Guryev Primorsk Shipping Co.		Nakhodka	1990		RR Russian Federation		
Kotlas Northern Shipping Company		Arkhangelsk	1989		RR Russian Federation		
Partizansk Primorsk Shipping Co. Oy Laivateollisuus Ab		Nakhodka	1988	First	RR Russian Federation		8700096
Petropavlovsk-Kamchatsk Kamchatka Shipping Co.		Petropavlovsk-Kamchatskii	1989		RR Russian Federation		
Roschino Primorsk Shipping Co.		Nakhodka	1990		RR Russian Federation		
Shkotovo Primorsk Shipping Co.		Nakhodka	1990		RR Russian Federation		
Svobodnyi Primorsk Shipping Co.		Nakhodka	1989		RR Russian Federation		

Pavlin Vinogradov			7 ships		UL		rank: 3
131.60	19.30	8.80	SSDG	1	14.9	CONV	MPC
122.00		6395		FPP	6500n.mi		
			4690	4		30	
7.00	11249	7850					

5800 t., cont: 274@20', cranes: 4@18.5 t.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Anatoliy Sibiryakov Northern Shipping Company		Arkhangelsk	1989		RR Russian Federation		
Iogann Makhmastal' Northern Shipping Company		Arkhangelsk	1990		RR Russian Federation		
Kapitan Glotov Northern Shipping Company		Arkhangelsk	1989		RR Russian Federation		
Kapitan Ponomaryov Northern Shipping Company		Arkhangelsk	1990		RR Russian Federation		
Pavlin Vinogradov Northern Shipping Company Stocznia Gdanska im. Lenina		Arkhangelsk	1987	First	RR Russian Federation		8419128
Teodor Nette Northern Shipping Company		Arkhangelsk	1988		RR Russian Federation		

Petrozavodsk	20 ships		L1		rank: 4

121.95	16.69	8.31	—	1	15.8	CONV	MPC
112.78	16.74	4562	—	FPP	—	—	
—			3825	4	—	—	
—			—	—	—	—	
7.15		6540					

cranes: 4@5 t.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Palanga Northern Shipping Company		Arkhangelsk	1969		RR Russian Federation		
Paramushir Sakhalin Shipping Co.		Kholmsk	1971		RR Russian Federation		
Pargolovo Northern Shipping Company		Arkhangelsk	1970		RR Russian Federation		
Paromay Sakhalin Shipping Co.		Kholmsk	1971		RR Russian Federation		
Pavlovo Sakhalin Shipping Co.		Kholmsk	1971		RR Russian Federation		
Pechenga Northern Shipping Company		Arkhangelsk	1970		RR Russian Federation		
Perm' Northern Shipping Company		Arkhangelsk	1969		RR Russian Federation		
Pertominsk Northern Shipping Company		Arkhangelsk	1968		RR Russian Federation		
Petrokrepost Northern Shipping Company		Arkhangelsk	1970		RR Russian Federation		
Petrovskiy Northern Shipping Company		Arkhangelsk	1970		RR Russian Federation		
Petrozavodsk Northern Shipping Company Vyborg Shipyard		Arkhangelsk	1968	First	RR Russian Federation		6923072

Plesetsk Northern Shipping Company	Arkhangelsk	1968	RR Russian Federation
Pomorje Northern Shipping Company	Arkhangelsk	1969	RR Russian Federation
Ponoy Northern Shipping Company	Arkhangelsk	1969	RR Russian Federation
Poronaysk Sakhalin Shipping Co.	Kholmsk	1972	RR Russian Federation
Primorje Sakhalin Shipping Co.	Kholmsk	1971	RR Russian Federation
Przhevalsk Sakhalin Shipping Co.	Kholmsk	1971	RR Russian Federation
Pulkovo Northern Shipping Company	Arkhangelsk	1970	RR Russian Federation
Pushlakhta Northern Shipping Company	Arkhangelsk	1971	RR Russian Federation
Pustozersk Northern Shipping Company	Arkhangelsk	1969	RR Russian Federation

Piere Radisson			3	ships		2		rank: 2
98.20	19.00	10.80	DIEL	2		16.0	—	CGIB
88.00	19.50	5910	10000	FPP		15000n.mi	18	
—			13010	4	4.1	1800 t.	75	
—			—	—		—	—	
7.20	8315	2865	1.15m @ 2kn					

Dick.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Franklin Department of the Coast Guard (Canada) Burrard Yarrows Co		Ottawa	1979		CR Canada		
Grosselier Department of the Coast Guard (Canada) Burrard Yarrows Co		Ottawa	1983		CR Canada		
Pierre Radisson Department of the Coast Guard (Canada) Burrard Yarrows Co		Ottawa	1978	First	CR Canada		7510834

Pioner			30 ships		L1		rank: 4
105.69	15.60	8.00	SSDG	1	13.8	CONV	MPC
96.00	15.63	3601	2150	FPP	8000n.mi	—	
—			2390	4	—	24	
—			—	—	—	—	
6.79	7240	4668					

4087 t.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Arkadiy Kamanin Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1972		RR Russian Federation		
Borya Tsarikov Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1971		RR Russian Federation		
Kolya Myagotin Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1969		RR Russian Federation		
Lara Mikheyenko Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1968		RR Russian Federation		
Lyonya Golikov Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1968		RR Russian Federation		
Marat Kazey Kamchatka Shipping Co.		Petropavlovsk-Kamchatskii	1968		RR Russian Federation		
Nina Kukoverova Murmansk Shipping Co.		Murmansk	1970		RR Russian Federation		
Pavlik Larishkin Murmansk Shipping Co.		Murmansk	1971		RR Russian Federation		
Pioner Kamchatka Shipping Co. Veb Shiftswerft Neptun		Petropavlovsk-Kamchatskiy	1968	First	RR Russian Federation		6727014
Pionerskaya Zor'ka Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1972		RR Russian Federation		
Sasha Borodulin AIF Shipping Company			1970		RR Russian Federation		

Sasha Kondratyev Far-Eastern Shipping Co. / Vladivostok	Vladivostok	1969	RR Russian Federation
Sasha Kotov Far-Eastern Shipping Co. / Vladivostok	Vladivostok	1972	RR Russian Federation
Shura Kober Murmansk Shipping Co.	Murmansk	1971	RR Russian Federation
Tolya Bodarchuk Murmansk Shipping Co.	Murmansk	1972	RR Russian Federation
Tolya Komar Polar Chart Company		1971	
Tolya Shumov Far-Eastern Shipping Co. / Vladivostok	Vladivostok	1970	RR Russian Federation
Valeriy Volkov Far-Eastern Shipping Co. / Vladivostok	Vladivostok	1970	RR Russian Federation
Valya Kotik Murmansk Shipping Co.	Murmansk	1968	RR Russian Federation
Vasya Korobko Murmansk Shipping Co.	Murmansk	1970	RR Russian Federation
Vitya Chalenko Far-Eastern Shipping Co. / Vladivostok	Vladivostok	1971	RR Russian Federation
Vitya Khomenko Far-Eastern Shipping Co. / Vladivostok	Vladivostok	1971	RR Russian Federation
Vitya Sitnitsa Far-Eastern Shipping Co. / Vladivostok	Vladivostok	1971	RR Russian Federation
Volodya Sherbatsevich Murmansk Shipping Co.	Murmansk	1972	RR Russian Federation
Yuta Bondarovskaya Murmansk Shipping Co.	Murmansk	1970	RR Russian Federation
Zina Portnova Far-Eastern Shipping Co. / Vladivostok	Vladivostok	1968	RR Russian Federation

Pioner Moskvy	22 ships	UL	rank: 3

129.95	17.00	8.54	SSDG	1	15.6	CONV	MPC
119.03	17.33	4814	4050	FPP	6500n.mi	—	
—			4490	4	—	25	
—			—	—	—	—	
7.34	10010	6780					

5265 t.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES / HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Pavel Korchagin Northern Shipping Company	Arkhangelsk	1980		RR Russian Federation		
Pioner Arkhangelska Northern Shipping Company	Arkhangelsk	1974		RR Russian Federation		
Pioner Belorussii Northern Shipping Company	Arkhangelsk	1978		RR Russian Federation		
Pioner Buryatii Sakhalin Shipping Co.	Kholmsk	1977		RR Russian Federation		
Pioner Chukotki Far-Eastern Shipping Co. / Vladivostok	Vladivostok	1975		RR Russian Federation		
Pioner Estonii Northern Shipping Company	Arkhangelsk	1976		RR Russian Federation		
Pioner Kamchatki Sakhalin Shipping Co.	Kholmsk	1976		RR Russian Federation		
Pioner Karelii Northern Shipping Company	Arkhangelsk	1978		RR Russian Federation		
Pioner Kazakhstana Northern Shipping Company	Arkhangelsk	1979		RR Russian Federation		
Pioner Kholmska Sakhalin Shipping Co.	Kholmsk	1974		RR Russian Federation		
Pioner Kirghizii Far-Eastern Shipping Co. / Vladivostok	Vladivostok	1978		RR Russian Federation		

Pioner Litvy Northern Shipping Company	Arkhangelsk	1977		RR Russian Federation	
Pioner Moldavii Northern Shipping Company	Arkhangelsk	1979		RR Russian Federation	
Pioner Moskvy Northern Shipping Company Vyborg Shipyard	Arkhangelsk	1973	First	RR Russian Federation	7334785
Pioner Oneghi Northern Shipping Company	Arkhangelsk	1975		RR Russian Federation	
Pioner Rossii Sakhalin Shipping Co.	Kholmsk	1976		RR Russian Federation	
Pioner Severodvinska Northern Shipping Company	Arkhangelsk	1975		RR Russian Federation	
Pioner Slavyanki Far-Eastern Shipping Co. / Vladivostok	Vladivostok	1975		RR Russian Federation	
Pioner Uzbekistana Sakhalin Shipping Co.	Kholmsk	1980		RR Russian Federation	
Pioner Yakutii Northern Shipping Company	Arkhangelsk	1977		RR Russian Federation	
Pioner Yu. Sakhalinska Sakhalin Shipping Co.	Kholmsk	1974		RR Russian Federation	

Polar Circle | | | **IA Super** | | | **rank: 3**

91.00	17.90	9.30	MSDG	1	14.9	CONV	PASS
82.50		5129		CPP			RV
6.50		2200	6000	4 4.0		35	
				Nozzles			
			1 m. @3 kn.				

2100 t. + 24 cont. + 95 pass.

Double-hull design. Bow & stern thrusters.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Polar Circle UK Navy Dept. Ulstein Hatlo A/S			1990	First	DNV Great Britain		8901561

Polar Duke			1 ships			IAA		rank: 3
66.80	13.10	9.50	—	1		14.0	—	RV
58.20		1649		CPP		12000 n.mi./90 days		
5.80	1400		3300	4	2.8	870 t.	14	
5.20			—	—		—	—	

cranes: 1@12.5 t.

Room for 26 persons, plus crew

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Polar Duke Vaagen Verft		Bergen	1983	First	DNV Norway		

Polar Star	2 ships				rank: 1

121.60	24.40	13.20
107.30	25.50	
8.50		
—		44700
	13190	

TUEL	3	21.0	CONV	CGIB
—	CPP	28300n.mi	15	
13235	4 4.9	—	138	
—	—	—	—	
1.83m @ 3kn				

Hangar and landing pad for 2 helicopters.

Dick.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Polar Sea US Coast Guard Lockheed SB & Construction Co		Seattle, WA	1978		ABS U.S.A.		
Polar Star US Coast Guard Lockheed SB & Construction Co		Seattle, WA	1976	First	ABS U.S.A.		7367471

Polarstern			1 ships			Arc2		rank: 1
118.00	24.40	13.60	MSDG	2		16.6	CONV	IB
102.20	25.00	10878	12400	CPP		—	22	RV
10.50	15000		14700	4	4.1	—	36	SUPP
			230	Nozzles		—	—	
—		4374	1.0m@5.2kn					

Dick.

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Polarstern Bundesminister fur Forschung und Tech. (Germany Howaldtswerke - Deutsche Werft AG		Bremerhaven	1982	First	GL Germany		8013132

Posiet	4 ships	L1	rank: 4

103.00	17.00	9.65
93.40		4295
—		
—		
7.20	7121	3657

SSDG	1	17.0	CONV	REFR
—	FPP	10000n.mi	—	
7502	4	—	18	
—	—	—	—	

2825t., cont: 62@20'

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Gorno-Altaysk Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1990		RR Russian Federation		
Posyet Far-Eastern Shipping Co. / Vladivostok Hellenic Shipyards		Vladivostok	1988	First	RR Russian Federation		8576615
Slavyanka Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1989		RR Russian Federation		

Povenets			23 ships		L1		rank: 4
105.85	14.60	8.00	SSDG	1	13.5	CONV	MPC
96.00		3726	2150	FPP	8000n.mi	—	
—			2390	4	—	24	
—			—	—	—	—	
6.56	6681	4150					

3832 t.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Bukhtarma Aspol Shipping Co. Ltd.		Murmansk	1966				
Kovdor Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1967		RR Russian Federation		
Murman Murmansk Shipping Co.		Murmansk	1967		RR Russian Federation		
Olenegorsk Murmansk Shipping Co.		Murmansk	1965		RR Russian Federation		
Povenets			1963	First	RR		
Svirsk AKFES Shipping			1966				
Ussuri Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1966		RR Russian Federation		

Professor Goryunov				L1		rank: 4

110.10		9.10
101.00	20.40	9096
6.50		5400
—		

—	1	13.8	—	DRED
	CPP	—		
7156	4	—	48	
—	—	—	Thrusters	
—	—	—		

Bow thrusters @500 kW.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Professor Goryunov IHS Smith		Vyborg	1986		RR Russian Federation		8505678

Rheinstern	**4 ships**	**E3**		**rank: 4**

161.36		11.70	MSDG	—	14.7	CONV	CHEM
153.00	23.00		—	—	8000	45	TANK
8.50		17000	6600	—	—	23	
8.60			—	—	—	—	

20340 m^3

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Rheinstern Rigel Schiffahrts MTW Schiffbau Werft			1993		GL		

Sakhalin-1	10 ships		UL		rank: 3

_		DIEL	2	16.8	CONV	FERR
_	5025	_	_	_	_	PASS
		2820	4	_	_	RORO
_		_	_	_	_	
_	2427					

rail vehicles: 26, stern door

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Sakhalin-1 Sakhalin Shipping Co. Kaliningrad Shipyard		Kholmsk	1972	First	RR Russian Federation		7223601
Sakhalin-10 Sakhalin Shipping Co.		Kholmsk	1992		RR Russian Federation		
Sakhalin-2 Sakhalin Shipping Co.		Kholmsk	1973		RR Russian Federation		
Sakhalin-3 Sakhalin Shipping Co.		Kholmsk	1974		RR Russian Federation		
Sakhalin-4 Sakhalin Shipping Co.		Kholmsk	1975		RR Russian Federation		
Sakhalin-5 Sakhalin Shipping Co.		Kholmsk	1976		RR Russian Federation		
Sakhalin-6 Sakhalin Shipping Co.		Kholmsk	1978		RR Russian Federation		
Sakhalin-7 Sakhalin Shipping Co.		Kholmsk	1982		RR Russian Federation		
Sakhalin-8 Sakhalin Shipping Co.		Kholmsk	1984		RR Russian Federation		
Sakhalin-9 Sakhalin Shipping Co.		Kholmsk	1986		RR Russian Federation		

Samotlor			14 ships		UL		rank: 3
160.00	23.00	12.90	SSDG	1	15.7	CONV	TANK
148.00	23.04	13204	—	FPP	10000n.mi		
—			8538	4	—	25	
—			—	—	—	—	
9.20	24570	17200					

15180 t., pumps: 6

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
BAM Primorsk Shipping Co.		Nakhodka	1977		RR Russian Federation		
Beryozovo Primorsk Shipping Co.		Nakhodka	1975		RR Russian Federation		
Gornopravdinsk Primorsk Shipping Co.		Nakhodka	1976		RR Russian Federation		
Igrim Primorsk Shipping Co. Rauma-Repola Oy		Nakhodka	1978		RR Russian Federation		7413476
Kamensk-Uralskiy Primorsk Shipping Co.		Nakhodka	1977		RR Russian Federation		
Nadym Primorsk Shipping Co.		Nakhodka	1976		RR Russian Federation		
Nizhnevartovsk Primorsk Shipping Co.		Nakhodka	1976		RR Russian Federation		
Samotlor Primorsk Shipping Co. Rauma-Repola Oy		Nakhodka	1975	First	RR Russian Federation		7359333
Urengoy Primorsk Shipping Co.		Nakhodka	1975		RR Russian Federation		
Usinsk Primorsk Shipping Co.		Nakhodka	1976		RR Russian Federation		
Viluysk Primorsk Shipping Co.		Nakhodka	1977		RR Russian Federation		

Yeniseysk		1977	RR
Primorsk Shipping Co.	Nakhodka		Russian Federation

Seapower			IA			rank: 4
	12.80	5.80	—	—	—	—	SUPP
60.39		919	—	—	—	—
4.77			5176	4	—	—
—			—	—	—	—

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Seapower / Teraoka SB Co.Ltd.		Panama			ABS		7500706

Sergei Kirov	2 ships	L1	rank: 4

156.60	23.80	16.90
142.00		6789
—		
8.83	21260	12010

SSDG	2	17.6	CONV	RORO
7920	CPP	12000n.mi		
8700	4	—	23	
—	—	—	—	

9940 t.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Pavlovsk Baltic Shipping Co.		St. Petersburg	1992		RR Russian Federation		
Sergei Kirov Baltic Shipping Co.		St. Petersburg	1989	First	RR Russian Federation		

Sestroretsk			5 ships		UL		rank: 3
130.30	17.30	8.50	SSDG	1	15.2	_	CONT
119.00	17.35	4786	_	FPP	7300n.mi	_	
_			4046	4	_	_	
_			_	_	_	_	
6.91	9826	6010					

3815 t., cont: 218@20'

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Pioner Nakhodki Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1972		RR Russian Federation		
Pioner Primorya Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1973		RR Russian Federation		
Pioner Vladivostoka Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1972		RR Russian Federation		
Pioner Vyborga Baltic Shipping Co.		St. Petersburg	1973		RR Russian Federation		
Sestroretsk Baltic Shipping Co. Vyborg Shipyard		St. Peterburg	1972	First	RR Russian Federation		7203261

SevMorPut	1 ships	ULA	rank: 2

260.30	31.60	18.30
228.80	32.20	38226
10.70	54380	25480
11.70	61880	33980

NPTE	1	20.8	CONV	LASH
21625	CPP	Unlimited	30	
29410	4 6.7	—	70	
350	Nozzles	—	—	
1.5m				

29700 t. @Dwtmax; 22200 t. @Dwl,
124 lighters or 1324 cont.

Ivanov; Sytov; Simonov; Tsoy (1993); Tsoy (1992); Tsoy (1990).

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
SevMorPut Murmansk Shipping Co. Zaliv Shipyard		Murmansk	1988	First	RR Russian Federation		8729810

Shiraze			1 ships					rank: 1
134.00	27.00	14.50	DIEL	3		19.0	CONV	ASRV
127.00	28.00		—	FPP		—	21	IB
9.80	18600		—	4	4.9	—	—	RV
9.50			—	—		—	—	
			1.5m @ 3kn					

Dick; Tsoy (1993).

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Shiraze Mitsubishi Heavy Industries			1982	First			

Shuhle Geteborg **IA** **rank: 4**

87.50		5.00	
82.50	13.00		
3.60		2050	

	1			BULK
2000	CPP			TANK
2370	4 2.7			
	Nozzles			

1540 t. of lumber materials or 2500 m^3 of oil.

SISTER SHIPS

SHIP NAME	FORMER NAMES		YR BUILT	First?	ICE RE	REG	LLOYD REG#
SHIP OWNER		HOME PORT			FLAG		
SHIPYARD		(MODERNIZATION)			(NOTES)		
(SPECIAL FEATURES)		(CHARTER RATE AND OP. COSTS)					
Shuhle Geteborg			1990		DNV		

SibirLes			**12 ships**		**L1**		**rank: 4**
104.40	14.33	7.12	SSDG	1	13.5	CONV	MPC
94.50	14.37	3179	1910	FPP	6000n.mi	—	
—			2130	4	—	24	
—			—	—	—	—	
6.37	6000	4140					

3379 t.

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Aldan			1967				
Ayan Sakhalin Shipping Co.		Kholmsk	1966		RR Russian Federation		
Egvekinot Sakhalin Shipping Co.		Kholmsk	1965		RR Russian Federation		
Kem' Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1967		RR Russian Federation		
Korsakov Sakhalin-Lyaonin			1965		Russian Federation		
Lakhta Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1967		RR Russian Federation		
Omolon Sakhalin Shipping Co.		Kholmsk	1966		RR Russian Federation		
SibirLes Sakhalin Shipping Co. Nosenko Shipyard		Kholmsk	1964	First	RR Russian Federation		6505363
Sibirtsevo Sakhalin Shipping Co.		Kholmsk	1965		RR Russian Federation		
Terney Sakhalin Shipping Co.		Kholmsk	1965		RR Russian Federation		
VyatkaLes Sakhalin Shipping Co.		Kholmsk	1965		RR Russian Federation		

Vzmorje		1966	RR
Sakhalin Shipping Co.	Kholmsk		Russian Federation
Yana		1966	RR
Sakhalin Shipping Co.	Kholmsk		Russian Federation

Sibirski **rank: 4**

—		—	—	—	—	BULK
—		1250	—	—	—	TANK
—	3200	—	—	—	—	
—		—	—	—	—	

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Sibirski 2101 / Wartsilla Shipyards			1980	First	RR / Russian Federation		
Sibirski 2102 / Wartsilla Shipyards			1980		RR / Russian Federation		
Sibirski 2103 / Wartsilla Shipyards			1980		RR / Russian Federation		
Sibirski 2104 / Wartsilla Shipyards			1980		RR / Russian Federation		
Sibirski 2105 / Wartsilla Shipyards			1980		RR / Russian Federation		
Sibirski 2106 / Wartsilla Shipyards			1980		RR / Russian Federation		
Sibirski 2107 / Wartsilla Shipyards			1980		RR / Russian Federation		
Sibirski 2108 / Wartsilla Shipyards			1980		RR / Russian Federation		
Sibirski 2109 / Wartsilla Shipyards			1980		RR / Russian Federation		
Sibirski 2121 / Wartsilla Shipyards			1980		RR / Russian Federation		

Sosnovets	11 ships		L1		rank: 4

80.19		5.60	MSDG	1	12.2	CONV	MPC
71.20	11.94	1531	990	FPP	4000n.mi	—	
—			1100	4	—	21	
—			—	—	—	—	
4.60	2835	1635					

1425 t., cranes: 3@5 t.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Cherepovets Northern Shipping Company		Arkhangelsk	1970		RR Russian Federation		
Sernovodsk Kamchatka Shipping Co.		Petropavlovsk-Kamchatskii	1972		RR Russian Federation		
Slautnoye Kamchatka Shipping Co.		Petropavlovsk-Kamchatskii	1973		RR Russian Federation		
Snezhnogorsk Kamchatka Shipping Co.		Petropavlovsk-Kamchatskii	1972		RR Russian Federation		
Soflysk Kamchatka Shipping Co.		Petropavlovsk-Kamchatskii	1973		RR Russian Federation		
Sosnovets Northern Shipping Company Interprinderea Const. Navale Constanza		Arkhangelsk	1970	First	RR Russian Federation		7108033
Surgut Kamchatka Shipping Co.		Petropavlovsk-Kamchatskii	1973		RR Russian Federation		

Sovetskaya Yakutiya			8 ships		L1		rank: 4
123.50	15.00	6.50	MSDG	2	11.2	CONV	MPC
117.00	15.04	3590	1324	FPP	5000n.mi		
—			1472	4	—	24	
—			—	—	—	—	
4.50	6142	4000					

3700 t., cranes: 2@8 t.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Afanasiy Bogatyryov YakutMorTransObyedineniye			1973		RR Russian Federation		
Fyodor Okhlopkov YakutMorTransObyedineniye			1974		RR Russian Federation		
Fyodor Popov YakutMorTransObyedineniye			1974		RR Russian Federation		
Isidor Barakhov YakutMorTransObyedineniye			1974		RR Russian Federation		
Ivan Strod YakutMorTransObyedineniye			1975		RR Russian Federation		
Maksim Ammosov YakutMorTransObyedineniye			1975		RR Russian Federation		
Platon Oiunskiy YakutMorTransObyedineniye			1975		RR Russian Federation		
Sovietskaya Yakutiya Northern Shipping Company Navashinskiy Shipyard		Arkhangelsk	1972	First	RR Russian Federation		7235355

Sovetskii Voin	20 ships	L1		rank: 4

82.00	12.48	6.02	—	—	12.7	CONV	MPC
74.21	12.53	1684			—	—	
—			1839	4			
5.40			—	—	—	—	
—			—	—	—	—	
		2485					

cranes: 2@8 t.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Aleksandr Miroshnikov Northern Shipping Company		Arkhangelsk	1971		RR Russian Federation		
Aleksandr Pankratov Northern Shipping Company		Arkhangelsk	1969		RR Russian Federation		
Andrey Ivanov Northern Shipping Company		Arkhangelsk	1970		RR Russian Federation		
Arseniy Moskvin Northern Shipping Company		Arkhangelsk	1969		RR Russian Federation		
Konstantin Korshunov Northern Shipping Company		Arkhangelsk	1970		RR Russian Federation		
Konstantin Savelyev Northern Shipping Company		Arkhangelsk	1969		RR Russian Federation		
Konstantin Shestakov Northern Shipping Company		Arkhangelsk	1968		RR Russian Federation		
Leningradskiy Opolchenets Northern Shipping Company		Arkhangelsk	1970		RR Russian Federation		
Leningradskiy Partizan Northern Shipping Company		Arkhangelsk	1970		RR Russian Federation		
Nikolay Yemelyanov Northern Shipping Company		Arkhangelsk	1971		RR Russian Federation		
Sovetskiy Moryak Northern Shipping Company		Arkhangelsk	1971		RR Russian Federation		

Sovetskiy Pogranichnik Northern Shipping Company	Arkhangelsk	1970		RR Russian Federation	
Sovietskiy Voin Northern Shipping Company Vyborg Shipyard	Arkhangelsk	1968	First	RR Russian Federation	6908929
Vyacheslav Denisov Northern Shipping Company	Arkhangelsk	1971		RR Russian Federation	
Vyborgskaya Storona Northern Shipping Company	Arkhangelsk	1970		RR Russian Federation	
Yakob Kunder Northern Shipping Company	Arkhangelsk	1970		RR Russian Federation	
Yakov Reznichenko Northern Shipping Company	Arkhangelsk	1971		RR Russian Federation	
Yevgeniy Nikonov Northern Shipping Company	Arkhangelsk	1969		RR Russian Federation	

Spartak			14 ships		L1		rank: 4
77.81	11.50	5.60	MSDG	1	12.5	CONV	TIMB
69.74		1505	990	FPP	—	—	
—			1100	4	4000n.mi	21	
—			—	—	—	—	
4.35	2550	1469					

1234 t.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Ivan Bolotnikov Northern Shipping Company		Arkhangelsk	1969		RR Russian Federation		
Kondratiy Bulavin Northern Shipping Company		Arkhangelsk	1969		RR Russian Federation		
Nikolay Bauman Northern Shipping Company		Arkhangelsk	1968		RR Russian Federation		
Pyotr Kakhovski Northern Shipping Company		Arkhangelsk	1969		RR Russian Federation		
Salavat Yulayev Northern Shipping Company		Arkhangelsk	1969		RR Russian Federation		
Spartak Murmansk Shipping Co.		Murmansk	1968	First	RR Russian Federation		

Stakhanovets Kotov	2 ships		L1		rank: 4

139.50	20.20	12.60
121.00	20.25	4026
—		
6.28	11149	5710

MSDG	2	14.2	CONV	HLV
4240	CPP	20000n.mi	—	RORO
4810	4	—	25	
—	—	—	—	

4200 t., cont: 286@20', cranes: 2@350 t., stern door/ramp

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Stakhanovets Kotov Baltic Shipping Co. Hollming Oy-Rauma		St. Petersburg	1978	First	RR Russian Federation		7616767
Stakhanovets Yermolenko Baltic Shipping Co.		St. Petersburg	1978		RR Russian Federation		

Stroptivyi			5 ships		UL		rank: 3
69.75	17.62	9.02	—	2	15.0	—	SALV
60.84	18.01	2635	—	CPP	—	—	TUG
6.46		1300	5590	—	—	Thrusters	
—			—	—	—		

Bow thrusters.

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Sibirsky DalRyba Wartsilla Shipyards		Vladivostok	1980		RR Russian Federation		7808308
Spravedlivyy DalRyba Wartsilla Shipyards		Vladivostok	1980		RR Russian Federation		7808279
Stakhanovets SevRyba Wartsilla Shipyards		Murmansk	1980		RR Russian Federation		7808281
Stroptivyi Klaipeda Transflot Wartsilla Shipyards	Jupiteris	Klaipeda	1979	First	Lithuania		
Suvorovets DalRyba Wartsilla Shipyards		Vladivostok	1980		RR Russian Federation		

SukhonaLes		
100.84	14.33	7.14
93.91	14.43	3036
5.78		3340
—		

L1

rank: 4

MSDG	—	—	—	MPC
— 1471	—	—	—	
—	—	—	—	
—	—	—	—	

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
SukhonaLes Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1964		RR Russian Federation		6521202

Svetlomor-1					L1		rank: 4
61.02	14.00	6.00	—	2	12.6	CONV	TUG
51.80		1695	—	CPP	—	—	
4.50			—	4	—	—	
—			—	—	—	—	
		1000					

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Svetlomor-1 Baltic Shipping Co. Far East - Levingston S. B. Ltd.		St. Petersburg	1987	First	RR Russian Federation		8606460
Svetlomor-3 Murmansk Basin Authority			1987		RR Russian Federation		

Taimyr	2 ships	LL2	rank: 1

150.00	28.00	15.20
140.60	29.20	20791
8.10	19600	
—		3581

NPTE	3	1:1:1	20.2	CONS	IB
32500	FPP		Unlimited	23	
36800	4		—	110	
—	—		—	—	
1.98m @ ~2kn					

Tsoy (1989); Tsoy (1993); Tsoy (1992); Tsoy (1990).

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Taymyr Murmansk Shipping Co. Wartsilla Shipyards		Murmansk	1989	First	RR Russian Federation		8417481
Vaygach Murmansk Shipping Co.		Murmansk	1989		RR Russian Federation		

Tebo Olimpia			1 ships		IA		rank: 4
140.80	21.20	10.70	—	1	15.0	—	TANK
132.80	21.23	8825	—	CPP	—	—	
7.30		11474	5560	4	—	—	
—			—	—	—	Thrusters	

pumps: 9@18000 t/hr.

Bow thrusters

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Tebo Olimpia Suomen Petrooli Oy Valmet Oy Helsingin Telakka		Helsinki		First	FR Finland		7813327

Temriuk | | | **L1** | **rank: 4**

83.55	11.97	5.34	MSDG	_	13.5	_	TANK
74.00	12.04	1611	_	_	_	_	
4.65		1660	1471	_	_	_	
_			_	_	_	_	

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Beloyarsk Kamchatka Shipping Co.		Petropavlovsk-Kamchatskii	1970		RR Russian Federation		7044378
Icha Kamchatka Shipping Co.		Petropavlovsk-Kamchatskii	1971		RR Russian Federation		7119458

Terry Fox	2 ships	4	rank: 1

88.00	17.50	10.00
75.00	17.94	4233
8.29	6910	
—		1708
8.30		2113

SSDG	2	14.0	CONS	IB
—	CPP	—	23	SUPP
17060	4 4.8	1650 t.	—	TUG
—	—	—	—	
1.2m@7kn				

800t.

Low-friction, abrasion-resistant coating "Inerta-60"

Helicopter landing pad.

Dick.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Kalvik Burrard Yarrows Co					CR Canada		
Terry Fox Department of the Coast Guard (Canada) Burrard Yarrows Co		Vancouver	1983	First	CR Canada		803579

Thuleland	1 ships	IA SUPE	rank: 3

185.90	26.50	15.05
177.00		22157
11.00		31900
—		31400

MSDG	1	—	—	BULK
—	FPP	—	—	
11200	4	—	—	
—	—	—	—	

cont: 832@20', cranes: 5@25 t.

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Thuleland Eriksberg M.V. A.B.		Singapore	1977	First	DNV Sweden		7519270

Trans Dania				IA			rank: 4
113.60	17.50	11.00	MSDG	1	15.0	CONC	MPC
106.40	17.75	5167		CPP		24	RORO
6.71		5353	3000	4 4.7			

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Trans Dania A/S Dania Transport K/S German Surken		Bergen	1990		DNV Norway		

Uglegorsk | **L1** | **rank: 4**

97.80	17.30	7.00	SSDG	1	13.1	—	MPC
90.22		3936	—	CPP	—	—	
5.62		4168	3360	—	—	—	
—			—	—	—	—	

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Chekhov Sakhalin Shipping Co.		Kholmsk	1993		RR Russian Federation		
De Kastri Sakhalin Shipping Co.		Kholmsk	1992		RR Russian Federation		
Gastello Sakhalin Shipping Co.		Kholmsk	1993		RR Russian Federation		
Nevelsk Sakhalin Shipping Co.		Valenta	1991		RR Russian Federation		
Nikolay Kantemir Sakhalin Shipping Co.	Baykovo	Kholmsk	1992		RR Russian Federation		8901004
Nogliki Sakhalin Shipping Co.		Kholmsk	1992		RR Russian Federation		
Novokubansk Sakhalin Shipping Co.	Shelikhova	Kholmsk	1992		RR Russian Federation		8900995
Orient Makarov Makarov Shipping Co.	Makarov	Vallenta	1991		RR Malta		8817825
Uglegorsk Mietfinanz G.m.b.h.		Nassau	1990	First	RR Bahamas		8817813

Uikku			1 ships		IA Super		rank: 3
164.47	21.50	12.02	DIEL	1	—	—	TANK
151.54	22.26	11290	11400	APD	—	—	
9.50		16500	12000	4	—	—	
—			—	—	—	—	

pumps: 8@2560 t/hr.

Formerly from "Lunni" series. Converted in 1993 to accomodate the 11.4 MW azimuthing propulsion drive "Azipod". Original medium-speed diesel, gearing, shafting, and CP propeller werereplaced.

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Uikku Neste Oy Verft Nobizkrug Gmbh.		Naantal/Nadendal	1976	First	DNV Finland	FR	7500401

Valentin Shashin		
149.40	24.00	12.60
136.80		11285
7.30	16810	7000
—		7245

		UL		rank: 3
DIEL	—	13.0	—	DRIS
—	—	—	—	
12800	4	—	100	
—	—	—	—	

Cranes: 1@25 t., 1@40 t.

Can drill to 6500 m. depth iin water 300 m. deep. Drilling rig is 48.8 m. tall, lifting capacity 454 t.

Elisavetchenko.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Valentin Shashin		Murmansk	1982	First	RR Russian Federation		7907166

Vanino | **UL** | **rank: 3**

113.01	18.30	8.51	—	1	14.0	—	TANK
105.24	18.53	5154	—	—	—	—	
7.20	8596		3960	—	—	24	
—			—	—	—	—	
		6237					

pumps: 11

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
Vanino Primorsk Shipping Co.		Nakhodka	1985		RR Russian Federation	FR	8406527

Vasilii Pronchischev	14 ships		LL4		rank: 2
67.70 17.50 8.30	DIEL	3 1:1+0.7	14.5	CONS	IB
62.20 18.10	3450	CPP	17days	25	
6.00 3100	3960	4	—	39	
—	—	—	—	—	
	0.7m @ ~2kn				

2 fore & 1 aft prop. Tsoy (1993).

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Fyodor Litke Sakhalin Shipping Co.		Kholmsk	1970		RR Russian Federation		
Ivan Kruzenshtern Leningrad Sea Transport			1964		RR Russian Federation		
Ivan Moskvitin Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1971		RR Russian Federation		
Khariton Laptev Sakhalin Shipping Co.		Kholmsk	1962		RR Russian Federation		
Pyotr Pakhtusov Arkhanghelsk Hydrography			1969		RR Russian Federation		
Semyon Dezhnev Leningrad Sea Transport			1971		RR Russian Federation		
Vasilii Pronchischev				First	RR Russian Federation		
Yerofey Khabarov Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1963		RR Russian Federation		
Yuriy Lisyanskiy Baltic Basin Administration			1965		RR Russian Federation		

Ventspils			10 ships		UL		rank: 3
113.00	17.06	8.50	SSDG	1	15.2		TANK
105.33	18.32	5154		FPP	4970n.mi		
			4350	4		28	
7.20	9400	6297					

4900 t., pumps: 11@1730 t/hr.

4 other sister ships in this series, unlisted in this database, are owned by Latvian Shipping Company.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Dallnerechensk Primorsk Shipping Co.		Nakhodka	1986		RR Russian Federation		
Daugava Primorsk Shipping Co.		Nakhodka	1985		RR Russian Federation		
Nagayevo Primorsk Shipping Co.		Nakhodka	1986		RR Russian Federation		
Ussurijsk Primorsk Shipping Co.		Nakhodka	1986		RR Russian Federation		
Ventspils Latvian Shipping Co. Rauma-Repola Oy		Riga	1983	First	RR Latvia		8129591

Viiralaid	5 ships		L1		rank: 4

80.20		8.32
70.80	12.89	964
—		
—		
4.17	2726	1455

MSDG	1	11.8	CONV	RORO
1398	CPP	4000n.mi	—	
1553	4	—	17	
—	—	—	—	

1274 t., cont: 115@20'

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Viirelaid Estonian Shipping Co. Ltd. Herman Suerken Gmbh and Co.		Tallinn	1971	First	RR Estonia		7125029

Vitalii Diakonov	11 ships		L1		rank: 4
124.24 15.80 7.50	MSDG	2	11.5	CONV	MPC
116.96 16.40 4643	1980	FPP	6000n.mi	60	
4.50 3370	2200	4 2.5		24	
5.50 8140 5031					

4599 t., 6680 m^3, cont: 165@20',
cranes: 4@8 t.

Nikonov.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Akademik Pozdyunin Sakhalin Shipping Co.		Kholmsk	1984		RR Russian Federation		
Nikolay Dolinskiy Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1988		RR Russian Federation		
Pavel Shepelyov Kamchatka Shipping Co.		Petropavlovsk-Kamchatskii	1985		RR Russian Federation		
Professor Bubnov Sakhalin Shipping Co.		Kholmsk	1984		RR Russian Federation		
Professor Papkovich Sakhalin Shipping Co.		Kholmsk	1985		RR Russian Federation		
Professor Victor Vologdin Sakhalin Shipping Co.		Kholmsk	1986		RR Russian Federation		
Professor Vladimir Popov Sakhalin Shipping Co.		Kholmsk	1987		RR Russian Federation		
Professor Voskresenskiy YakutMorTransObyedineniye			1988		RR Russian Federation		
Valeriy Kuzmin YakutMorTransObyedineniye			1986		RR Russian Federation		
Vitaliy Diakonov Sakhalin Shipping Co. Navashinskiy Shipyard		Kholmsk	1983	First	RR Russian Federation		8227434

Vitus Bering			5 ships		ULA		rank: 2
159.80	22.10	12.00	DIEL	1	16.4	CONS	IB
142.40	22.40	13514	9300	FPP	15000n.mi	29	RORO
7.50	16200	6500	11460	4		39	SUPP
8.50	18900	9200		Nozzles			
9.00	20350	10650	0.9m @ ~2kn				

8670 t. (7770 t.), cont: 326@20', cranes: 2@25 t. 1@12.5 t. All cargo holds can be unloaded by helicopters Ka32 with 5 t. cargo capacity. 2 ACV @40 t., 2 refr. holds @110 m^3, holds 4 & 5 for heavy wheeled machinery.

2 helicopters available, hangar 14x10x5.8 m.

Low-friction abrasion-resistant coating "Inerta-60".

Glebko; Kosovsky; Tsoy (1993); Tsoy (1992).

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Aleksey Chirikov Far-Eastern Shipping Co. / Vladivostok Kherson Shipyard		Vladivostok	1987		RR Russian Federation		
Stepan Krashennikov Far-Eastern Shipping Co. / Vladivostok Kherson Shipyard		Vladivostok	1989		RR Russian Federation		
Vasilliy Golovnin Far-Eastern Shipping Co. / Vladivostok Kherson Shipyard		Vladivostok	1988		RR Russian Federation		
Vitus Bering Far-Eastern Shipping Co. / Vladivostok Kherson Shipyard		Vladivostok	1987	First	RR Russian Federation		8624383
Vladimir Arsenjev Far-Eastern Shipping Co. / Vladivostok Kherson Shipyard		Vladivostok	1987		RR Russian Federation		

Vohilaid			UL				rank: 3
49.70		4.80	DIEL	2	12.5	—	FERR
—	12.80	820	1420	—	—	—	RORO
3.00			—	—	—	Thrusters	
—			—	—	—		

Bow thrusters @135 kW.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Vohilaid Estonian Shipping Co. Ltd. Riga Shipyards		Tallinn	1983	First	RR Estonia		8227173

VolgoLes	4 ships	L1	rank: 4

123.90	16.70	8.45	SSDG	1	14.8	CONV	TIMB
115.00		4638	2980	FPP	7000n.mi		
—			3310	4	—	25	
—			—	—	—	—	
6.82	9220	5895					

5166 t.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
AlatyrLes Baltic Shipping Co.		St. Petersburg	1962		RR Russian Federation		
DvinoLes Baltic Shipping Co.		St. Petersburg	1960		RR Russian Federation		
KomiLes Baltic Shipping Co.		St. Petersburg	1960		RR Russian Federation		
VolgoLes Baltic Shipping Co.		St. Petersburg	1960	First	RR Russian Federation		

Weserstern

2 ships | E3 | rank: 4

110.00	17.70	10.60	SSDG	1	12.5	CONV	CHEM
104.60		5480	3600	CPP	5000 mi.	45	TANK
8.54		9025	—	— 3.1	—	19	
—			—	—	—	—	

10000 m^3.

Double-hull design.

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Oderstern Chemical Carriers Ltd. MTW Schiffbau Werft		Douglas	1992		GL Great Britain		9035838
Weserstern Chemical Carriers Ltd. MTW Schiffbau Werft		Douglas	1992	First	GL Great Britain		9035826

World Discoverer					IA		rank: 4
	15.20	6.25	—	1	16.5	—	PASS
72.70		3153	—	CPP	—	—	
4.46	3080	720	3529	4	—	—	
—			—	—	—	—	

SISTER SHIPS

SHIP NAME SHIP OWNER SHIPYARD (SPECIAL FEATURES)	FORMER NAMES	HOME PORT (MODERNIZATION) (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE FLAG (NOTES)	REG	LLOYD REG#
World Discoverer Adventurer Cruises Inc. Schiffbau Ges.Unterweser A.G.		Monrovia	1974	First	ABS Liberia		7401269

Yasnyi				UL		rank: 3
81.16	15.97	7.22	—	2	15.3	CONV	SUPP
71.46	16.30	2737	—	CPP	—	—	TUG
4.90			—	4	—	—	
—			—	—	—	—	
		1329					

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Irbis Far Eastern Basin Administration			1986		RR Russian Federation		
Radon Sakhalin Basin Administration			1987		RR Russian Federation		
Umka Murmansk Basin Authority			1987		RR Russian Federation		
Yasnyi Baltic Shipping Co. Stocznia Gdanska im. Lenina		St. Petersburg	1985	First	RR Russian Federation		8422242

Yermak			3 ships			LL2		rank: 1
135.00	25.60	16.70	DIEL	3	1:1:1	19.5	CONS	IB
130.00	26.00	12231	26500	FPP		28days	26	
11.00	20240		30420	4	5.4		91	
		7560	1.8m @ ~2kn					

cranes: 2@10 t.

Tsoy (1993); Tsoy (1992); Tsoy (1990).

SISTER SHIPS

SHIP NAME / SHIP OWNER / SHIPYARD / (SPECIAL FEATURES)	FORMER NAMES	HOME PORT / (MODERNIZATION) / (CHARTER RATE AND OP. COSTS)	YR BUILT	First?	ICE RE / FLAG / (NOTES)	REG	LLOYD REG#
Admiral Makarov Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1975		RR Russian Federation		
Krasin Far-Eastern Shipping Co. / Vladivostok		Vladivostok	1976		RR Russian Federation		
Yermak Far-Eastern Shipping Co. / Vladivostok Oy Wartsila Ab		Vladivostok	1974	First	RR Russian Federation		7330038

SHIP OWNERS BY COMPANY NAME

Alphabetical listing of ship owner companies and the ships owned by them.

OWNER ENTRY LAYOUT

Company name Street or mailing address City, state/province, postal code, country	Telephone and fax Telex

Listing of ships owned (this listing does not attempt to list all ships owned by the company)

OWNERS LISTING

A/S Dania Transport K/S — **Tel: +5 91 22-30** — **Fax: +5 91 22-41**
Wernersholmvel 5, Postboks C. — **Telex: 42433 seatr**
Hop, 5043, Norway
Trans Dania

Academy of Sciences of Russian Federation
Akademik Ioffe — Akademik Sergei Vavilov

Adventurer Cruises Inc. — **Tel: +0421 238-030** — **Fax: +0421 238-0333**
W-2800
Bremen 34, Germany
World Discoverer

AIF Shipping Company
Sasha Borodulin

AKFES Shipping
Svirsk

Amoco Canada Research Ltd.
Canmar Kigiriak

Antarctic Shipping Pty. Ltd. — **Tel: +02 240-666** — **Fax: +02 240-053**
Suite 20, Galleria Salamanca, Salamanca Place — **Telex: 58247**
Hobart, Tasmania, Australia
Aurora Austrelis

Aqua Ltd. Shipping
Yuvent

Arctic and Antarctic Research Institute
, Russia

Mikhail Somov

Arkhanghelsk Hydrography

Ivan Kireyev	Nikolay Kolomeytsev	Pavel Bashmakov	Pyotr Pakhtusov
Serghey Kravkov	Valerian Albanov	Yakov Smirnitskiy	

Aspol Shipping Co. Ltd.
3A Pushkinskaya St.
Murmansk, Russian Federation
Telex: 126158 ASPOL SU

Bukhtarma

Azov Shipping Co.

Kapitan Belousov	Krymsk

Baikal Shipping Co.

Baykal

Baltic Basin Administration

Yuriy Lisyanskiy

Baltic Shipping Co.
5 Mezhevoi Kanal
St. Petersburg, Russian Federation
Tel: +7/812/216-9326 **Fax: +7/812/186-8544**
Telex: 121501 BSC SU

AlatyrLes	Aleksandr Prokofyev	DvinoLes	EPRON
Estonia	Gerakl	Guse-Khrustalnyi	Ilyich
Indiga	IrtyshLes	IzhmaLes	IzhoraLes
Jose Diaz	Kaliningrad	KamaLes	Kapitan Beklemishev
Kapitan Chmutov	Kapitan Gastello	Kapitan Gavrilov	Kapitan Goncharov
Kapitan Kanevskiy	Kapitan Kozlovskiy	Kapitan M. Izmailov	Kapitan Primak
Kharlov	Kimry	Kingisepp	KomiLes
Kosmonavt Pavel Beliayev	Kosmonavt V. Patsayev	Kosmonavt V. Volkov	KostromaLes
Krasnoborsk	Kuzminki	Ladogales	Ligovo
Lomonosovo	Mikhail Kalinin	NevaLes	Nikolay Tikhonov
Novaya Ladoga	Pavlovsk	Pioner Vyborga	Professor Tovstykh
Saldus	Sergei Kirov	Sestroretsk	Sofja Perovskaya
Stakhanovets Kotov	Stakhanovets Yermolenko	Svetlomor-1	Tikhon Kiselyov
Turku	Vasya Alekseyev	Velikiy Ustyug	VolgoLes
Yantarnyi	Yasnyi		

Bundesminister fur Forschung und Tech. (Germany)
, Germany

Polarstern

Canadian Marine Drilling
, BC, Canada

Canmar Explorer	Canmar Explorer II	Ikaluk	Miscaroo

Chemical Carriers Ltd.

Oderstern	Weserstern

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Since the advent of steam power, icebreakers have been built to navigate in ice-covered waters. The hull forms of early icebreakers were merely an adaptation of open water hull shapes, by sloping bow angles more to create vertical forces for breaking ice in bending. However, these bow forms were found to be unsuitable for sea-going vessels because they push broken ice ahead of them. This experience led to construction of all sea-going vessels with wedge-shaped bows from 1901 to 1979. With the introduction of low-friction coatings and the water-deluge system, it is now possible to operate ships with blunt bows efficiently in broken ice. New developments in marine propulsion technology have also been incorporated to obtain better icebreaking efficiency and performance. Both fixed-pitch and controllable-pitch propellers are in use. Nozzles surrounding the propellers are also used to increase the thrust and to reduce ice–propeller interaction. Electrical and mechanical transmission systems have been used in icebreakers to improve the characteristics of the propulsion system. Though many types of prime movers are used in icebreakers, medium-speed diesel engines are the most popular because of their overall economy and reliability. Appendix A is a description of the Russian icebreaker *Yamal,* which is one of the largest and most powerful icebreakers of the world today. Appendix B contains an inventory of existing ships that are capable of navigating in at least 0.3-m-thick ice. Some of the present icebreakers are capable of

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navigating almost anywhere in the ice-covered waters of the Arctic and the Antarctic, and multi-purpose icebreakers have been built to operate not only in ice during the winter but also in open water doing other tasks during the summer. With sufficient displacement, power, navigation equipment, and auxiliary systems, future icebreakers that can operate independently year-round in the Arctic and the Antarctic are well within the known technology and operational experience.